ADORE Update Version 6.50

Release Date: September 30, 2015

ADORE 6.50 is a major enhancement to earlier version 6.00. The following is a description of all updates:

1. Code Corrections

The temporary fix to ADORE materials data base, issued as a patch for updated version 6.01 is now permanent. In addition the following errors are corrected in version 6.50:

1. In roller bearing life equations, the life constants were not setup correctly for the newly introduced LP and GZ life models. This problem was corrected.
2. The number of arguments in user subroutine Adrx7 and the calling routine Adre1 did not match. This problem in corrected by adding another dummy argument in the calling statement in Adre1.
3. The inertial to azimuth transformation matrix for symmetrical solutions was corrected in Adrb1. This only affects the applied load computations on the races. Thus unless the races are accelerating under the applied loads this error does not change any of the results.
4. Missing scale factor of 1.0E-06 on values of coefficient of linear expansion of cronodor stainless steel was added in the materials database.

All shipments, labeled as version 6.01, made after 30April14 included the above corrections. More recently, related to the very rarely used visco-elastic traction model, the expression for Debrah number was corrected. Also the asymptotic term for large shear stresses was better defined.

2. Code Enhancements

2.1 Three and Four Point Contacts in Ball Bearing

Major revision of ADORE data structure was carried out to model the secondary contacts arising in split inner and outer races. The two halves of the split races are basically treated as separate race elements. Thus the number of race segments was changed from 2 to 4. A new parameter maxRS is introduced in module m_parameters.f, which is used in all the subroutines. This permit- ted an easy change of race dimensions from 2 to 4 in the entire data structure. Then the various subroutines responsible for calculating the ball to race interactions were modified to carry out the computations on all possible contacts.

In addition to the commonly used race control and minimum energy dissipation hypotheses for computing initial angular velocities in ball bearings, a new option (kAngVel =2) was introduced on input record 3.3 to specify an arbitrary orientation of ball angular velocity vector. The value of this angle is specified on record 9.0. Thus when the ball contacts on both sides of the race, the ball angular velocity vector may be kept parallel to the shaft axis, which is perhaps more realistic.

2.2 Fatigue Life Modeling

The second major enhancement in version 6.50 is conversion of load based fatigue equations to stress based formulations. Thus instead of dynamic load capacity, the equivalent parameter is now dynamic stress capacity. In order to maintain continuity with the load-based formulation, the dynamic load capacity, which may easily be derived from the stress capacity, is also included in the output. Although both formulations provide identical results, the stress-based formulations are more easily adaptable to implement the effects of residual and limiting shear stresses. The effects of residual stresses shall be implemented in the very near future.

The life equations were further generalized to segment the overall bearing life in terms of race and rolling element lives. Such a modeling was possible in both the updated LP and the newly formulated GZ equations. For the basic subsurface life the total bearing life is of course identical to that computed with earlier formulations, where the rolling element lives was actually included race lives. Thus for ball bearing the basic bearing life should be identical to that calculated earlier with version 6.00. The new formulation, however, provides an avenue for better modeling for hybrid bearings, where the fundamental life equation may be different for prescribed materials. Also, different life modification factors may be applied to each race and the rolling element; although presently the rolling element life modification factors are set equal to that at the races. It should be noted that the Tallian life modifications used a type of load distribution factor, which when applied to each individual rolling element, yields total modified bearing life slightly different from the earlier calculations. Thus for ball bearings, although the basic life is identical to that computed earlier, the Tallian modified life is somewhat different. The results are unchanged with the STLE life factors, since these factors are simply applied as multiplier over the basic life. The roller bearing lives in version 6.50, however, are different from those computed in version 6.00 due to: (1) correction to the roller bearing life constants, as discussed earlier, and (2) an arbitrary factor of 0.90 in the load capacity equation used earlier, to make the updated LP life almost identical to original LP life, is now removed under default conditions.

2.3 Materials Database

1. Properties of 440C and Cronodor stainless steels were modified to provide more accurate behavior under cryogenic conditions. While carrying out these modifications it was discovered that the multiplier of 1.0E-06 was missing from the values of coefficient of linear expansion of Cronodor stainless steel; this was corrected.
2. A new material code of 163 was also introduced to incorporate the properties of titanium alloy, Ti-6Al-4V.

3. ADORE User Manual

No changes have been made to ADORE user manual supplied with version 6.10. The users should rely on the updated input facility (AdrInput) to code the input data correctly.

4. ADORE Input, Plot and Animation Facilities

The input facility AdrInput was appropriately modified to provide new data as required by the new version 6.50. Note that older data sets may not work with the new version 6.50. However, the old input data sets may be opened with new AdrInput facility to convert the data files for use with ADORE 6.50.

There are no modifications to the plot (AdrPlot) and animation facilities (AGORE).

5. ADORE Print Output

The rolling element to race contact section of the print output is significantly modified to accommodate output for both primary and secondary contacts on the races. All the output variables are still the same but their location on the printed output has changed. See printed output of the attached test case for ball bearing for details.

Also, the life modeling section in the print output is significantly changed to show the computed race and rolling element lives.

6. Test Cases

As usual the input data, print output and all plot data sets are included in these subdirectories in the program media. These examples must be run and checked after installation of the program. All outputs, at least at step 0, must match against the supplied output.

7. Program File Contents:

As usual program updates are distributed on a CD in normal data format. The files may be easily extracted from this disk on any computer system and then transferred to appropriate system for which ADORE is licensed for.

The media contains the following three subdirectories and a **readMe.pdf** file which provides latest update information and instructions for quick installation on the Windows machine:

Disk1

Update650.pdf: A pdf file containing notes of the latest updates (this file

adoreInput.txt: A text file containing details of ADORE input data.

adoreManual.pdf: ADORE user's manual.

Ball: Subdirectory containing ball bearing test case.

Roller: Subdirectory containing roller bearing test case.

TaperedRoller: Subdirectory containing tapered roller bearing test case.

AdrxExamples: Subdirectory containing few of the user programmable examples.

Disk2

***.f files:** ADORE FORTRAN-90/95 source files.

makeIntel.txt: Makefile for Windows 7 machine with Intel Fortran compiler.

makeLahey.txt: Makefile for Windows 7 machine with Lahey Fortran compiler.

Disk3

setup.bat: Setup batch file to compile adrInput, adrPlot and AGORE on Windows system.

adrInput.bat: Batch file to execute adrInput.

adrPlot.bat: Batch file to execute adrPlot.

agore.bat: Batch file to execute the graphics animation facility, AGORE.

Java: Subdirectory containing all Java source files.

8. Program Installation

Quick installation steps are outlined in the readMe.txt file supplied on the program disk. More detailed installation are included in the users manual.

ADORE Installation

Make files are provided in Disk2 directory for easy installation of ADORE for both the Intel and Lahey compilers for a Windows machine. The nmake command available with these compilers may be used to compile and create an executable code.

Installation of Java facilities adrInput, adrPlot and Agore

Edit the setup.bat file in Disk3 subdirectory to correct the paths to all source files and the Java Development Kit. Execute the updated setup file to compile and install these facilities.

The setup files for the three applications may then be edited to update the paths and installed in appropriate directory compatible with the environmental variables which provide access to all executables.

9. Contact Information

In the event of any questions and/or technical support please contact:

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