ADORE Update Version 8.10

Release Date: March 31, 2020

Along with some minor code corrections, this release consists of a major rewrite of the procedure Adra5, which sets the angular velocities of rolling elements in the quasi-static equilibrium analysis. Following this update, the quasi-static and lubricant traction modules have been packaged into a stand-alone code, AdoreQS, and it is now offered, in executable form, as a complementary software.

1. Code Enhancements

In all earlier versions of ADORE the minimum energy hypothesis option for computation of ball angular velocities under quasi-static equilibrium was implemented as a simple modification of the solution obtained under the conventional race control hypothesis. The current enhancement is a more rigorous and realistic implementation, where the energy dissipated in the ball/race contact is minimized as a function of the orientation of ball angular velocity vector and the location of points of pure rolling in the outer and inner race contacts with a prescribed lubricant traction model. Since this optimization has to be carried out as a part of the ball equilibrium solution, three additional iteration loops are introduced within the ball equilibrium loop and the lubricant traction model is in the inner most loop. The three iteration loops correspond to the three independent variables, ball angular velocity vector orientation, and the points of pure rolling in the outer and inner race contacts, which control the frictional dissipation in the ball/race contacts. Depending on the complexity of the traction model, this makes the process very compute intensive. However, with the recent advancements in computing technology, and by introduction of partly intelligent numerical data base the required computing effort is within practical limits.

A parametric evaluation of a high-speed ball bearing, demonstrates that the ball angular velocity vector orientation as determined by the minimum energy hypothesis closely conform to the dynamic solution obtained by integration of the differential equations of ball motion to steady-state. Also, the frictional dissipation in ball/race contacts converges to that determined by the minimum energy hypothesis as the bearing reaches steady-state. Such an observation makes the quasi-static solution quite powerful in optimizing bearing life and contact heat generation, particularly for hybrid bearings where contact heat generation and fatigue life are competing issues. It is anticipated that such a parametric evaluation before undertaking a more sophisticated dynamic analysis may simplify the overall design process in advanced bearing applications.

Due to this added design capability of the simple quasi-static equilibrium solution, the quasi-static and lubricant traction modules are packaged into a stand-alone software, AdoreQS, which is now available, in executable form, as a complementary software. The package may be freely accessed at www.PradeepKGuptaInc.com/AdoreQS.html.

As a part of rewriting the procedure for computation of ball angular velocity vector, the points of pure rolling in race control solution are now in the center of contact, as commonly used in other quasi-static software codes. This results in a slight but insignificant change in ball angular velocity (at the level of third or fourth significant figure) when compare to earlier versions of ADORE.

2. Code Corrections

A few minor code corrections are also part of this update:

1. The missing scale factor in the load-slip integral for the rolling element to race contacts has been incorporated in the output procedure, Adra3.
2. In the input data record for arbitrary material property properties, the missing von-Mises stress has been added. Also, the print output for material properties now include both von-Mises and octahedral shear stress limit, as used in the Ioannides-Harris limiting stress life model.
3. Some variable initialization issues identified by some compilers have been rectified.
4. In the event the input data file DATA.txt is not found, and the output PRINT.txt file cannot be created, in the current run directory, a diagnostic message is now printed on the console. Earlier the message was only documented in virtual PRINT.txt file.

3. ADORE User Manual

There are no changes to the User Manual as a part of this update.

4. ADORE Input Facility, AdrInput

The optional material property records have been updated as a result of the above code correction.

5. ADORE Plot Facility, AdrPlot

There are no modifications to the plot facility Adrplot in this version.

6. ADORE Animation Facility, AGORE

There are no modifications to the animation facility (AGORE).

7. Test Cases

As usual the input data, print output and all plot data sets are included in the test cases subdirectories in the program folder. 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.

8. Program File Contents:

Since CD is no longer a desired or preferred media on most computer systems, all software deliveries are now made via internet link for immediate download. The downloaded zip file may be easily unzipped and the software may be installed on the computer system for which ADORE is licensed.

The media contains the following four subdirectories and a readMe.pdf file, which provides latest update information and instructions for quick installation on the Windows and Macintosh machines:

Disk1

Update810.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 machine with Intel Fortran compiler.

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

makeUnix.txt: Makefile for Intel compiler on a Unix and/or Macintosh operating system.

Disk3

Java: Subdirectory containing all Java source files.

Disk4

For convenience, this subdirectory contains immediately usable executable files for both Windows and Macintosh operating systems. Of course, all executables may be created by compiling the source codes supplied in Disk2 and Disk3 directories. The contents of Disk4 directory are as follows:

Windows: Windows subdirectory

Adore810.exe: Adore executable
AdrInput.jar: AdrInput (Java executable)
AdrPlot.jar: AdrPlot (Java executable)
Agore.jar: Agore (java executable)

Mac: Macintosh subdirectory

Adore810: Adore executable (Unix executable for Mac)
AdrInput.jar: AdrInput (Java executable)
AdrPlot.jar: AdrPlot (Java executable)
Agore.jar: Agore (java executable)

While ADORE is a command line applicable and it must be executed on a command line in appropriate directory containing the input data file DATA.txt, the java applications may be executed by a simple double click on the application icon. On command line the application may be executed by invoking the following command:

java -jar *jarFileName*

where *jarFileName* may be AdrInput.jar, AdrPlot.jar or Agore.jar. Of course, the path for the jar file must be satisfied.

9. Program Installation

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

9.1 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. In addition a make file is also included for a Unix operating system, running an Intel FORTRAN compiler. This file may also be used on a Macintosh computer, since Mac OS is based on Unix.

In case of other computing platforms and/or operating systems, any of the supplied make file may be appropriately edited and used for ADORE installation.

9.2 Installation of Java facilities AdrInput, AdrPlot and Agore

The freely available **Netbeans 8.2** Java Development IDE is used to create the java executable jar files as supplied in the Disk4 directory. This eliminates the more complicated command line procedures used in all earlier versions of ADORE. Netbeans 8.2 may be freely downloaded from Oracle website. This requires Java 1.8 Java Development Kit, which is also available from Oracle website. The Java JDK must be installed before installing Netbeans.

The jar files so created with Netbeans 8.2 are self-contained and do not require specification of any classpath statements. Also, since most Java applications are platform independent, the jar files may be used on both Windows and Macintosh operating system.

Please see the user manual or the ReadMe.pdf file for more details on using Netbeans 8.2 for compiling the java applications.

10. Contact Information

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

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