ADORE Update Version 9.00

Release Date: January 14, 2022

With continued enhancements to implementation of minimum energy hypothesis, changes to input/output geometrical parameters of tapered roller bearing constitute major part of this update.

1. Code Enhancements and Corrections

The following enhancements constitute the key elements of the current update.

Tapered Roller Bearing Geometry: The input roller diameter for a tapered roller bearing is now the mean diameter, which is the diameter at mid-section of the roller. Although this appears to be a simple change, it constitutes a major change in the code architecture. Making the geometrical definition of the tapered roller consistent with that of cylindrical and spherical roller results in a notable simplification in code logic. Therefore, the code structure in a number of subroutines in simplified. The change also affects the numerical time domain integration for tapered roller bearing, since the length scale is based on input roller radius. Thus, the nondimensional time step size and subsequent automation of step optimization process is affected. The overall time domain solutions for a given bearing are, of course, unchanged, although the step size and number of steps required over a given time interval may be somewhat different. The computed pitch diameter and race radii on the contacting surface are now included in the geometrical data output. Appropriate modification to the user's manual and input facility **AdrInput** are also made to reflect this geometrical update.

Minimum Energy Hypothesis Implementation: Enhancements to procedures in subroutine Adra5 continued to improve implementation of the minimum energy hypothesis. In particular version 9.00 offers the following enhancements:

1. The range over which orientation of ball angular velocity vector is scanned, is increased to accommodate a wider range of angular contact ball bearings. In version 8.51 for certain angular contact bearing the minimum energy point is beyond the scanning range, so execution is terminated with a diagnostic message.
2. For improved data handling during the dynamic simulations, the body-fixed x-axis of a ball is now set along the initial ball angular velocity vector.
3. The normalized point of pure rolling on the controlling race is now moved from contact center to 0.3473. Under constant friction coefficient this position provides no net traction force over the contact zone and the frictional dissipation is somewhat less than the value obtained when the rolling point is in center of the contact.
4. Some numerical enhancements to improve convergence for angular contact ball bearings with combined thrust and radial loads are also part of this enhancement.

Time-Varying Loads and Speeds: In all earlier versions of ADORE modeling of time-

varying loads and speeds required customized programming in user programmable subroutines. This update implements some of the most common variations at input data level. In particular, the following enhancements have been implemented:

1. The kRotLoad flag on input data record 3.4, used in earlier version of ADORE is now changed to kVarLoad with the following options:
   a. kVarLoad = 0, no load variation. Same as kRotLoad =0 in earlier versions.
   b. kVarLoad = 1, rotating load. Same as kRotLoad =1 in earlier versions.
   c. kVarLoad = 2, cyclic load variation corresponding to input sinusoidal displacement.
2. Input data record 9.3 is now replaced by records 9.3A and 9.3B corresponding to the above load variation options.
3. Introduced a new variable speed flag, kVarSpeed on input data record 3.4 with the following options:
   a. kVarSpeed = 0, no speed variation.
   b. kVarSpeed = 1, constant acceleration, or linear speed variation.
   c. kVarSpeed = 2, sinusoidal speed variation as in oscillatory bearings.
4. Added new input data records 9.4A and 9.4B corresponding to the above speed options.
5. Changed input data records 9.4 to 9.7 to new records 9.5 to 9.8.

Churning and Drag Fluids Database: Subroutine Adrf3, providing the fluids data base for modeling churning and drag effects and/or bearing coolant for thermal interactions is rewritten to access the property data from the data module, setup_f3. This streamlines the process of adding new fluids in the future. This update also adds the property data base for liquid natural gas (LNG). The data base is generated from the REFPROP software distributed by NIST (Lemmon, E.W., Bell, I.H., Huber, M.L., McLinden, M.O., 2018, NIST Standard Reference Database 23: Reference Fluid Thermodynamic and Transport Properties-REFPROP, Version 10.0, National Institute of Standards and Technology, Standard Reference Data Program, Gaithersburg). However, adequate number of rolling bearing applications using this fluid have yet to be tested.

Code corrections: In addition to the above enhancements the following code corrections have been implemented in this update:

1. Corrected input documentation in **AdrInput** for initial cage mass center position on Record 9.6 (old Record 9.5). The axial position (x-comp) is relative to average rolling element position, while y and z components are relative to the guiding race position.
2. Corrected cage pocket hi-lighting in **AGORE** for driving and driven rolling elements.
3. For the updated 23699 lubricant traction model with traction code, kTrac=11, the density and specific heat values are correctly set on the basis of deg-K rather than deg-C.
4. In customized modeling of angular acceleration of rotating race, appropriate increment to centrifugal expansion of the race is now incorporated.

2. ADORE User Manual

All input data records in the ADORE user manual have been updated to reflect all enhancements implemented in the current version 9.00.

3. ADORE Input Facility, AdrInput

The input facility, **AdrInput**, has been updated to include all changes to the input data as discussed above.

4. ADORE Plot Facility, AdrPlot

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

5. ADORE Animation Facility, AGORE

Minor updates to **AGORE** are implemented to correctly hi-light the cage pockets to indicate driving and driven rolling elements.

6. 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.

7. Program File Contents:

The program media supplied electronically in the media file **Adore900.zip** 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

Update900.pdf: A pdf file containing notes on 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 cylindrical 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: Make file for Windows machine with Intel Fortran compiler.

makeLahey.txt: Make file for Windows machine with Lahey Fortran compiler.

makeUnix.txt: Make file for Intel compiler on a Unix and/or Macintosh 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

Adore900.exe:	**ADORE** executable
AdrInput.jar:	**AdrInput** (Java executable)
AdrPlot.jar:	**AdrPlot** (Java executable)
Agore.jar:	**AGORE** (Java executable)

Mac: Macintosh subdirectory

Adore900:	**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 application 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.

8. Program Installation

Quick installation steps are outlined in the **readMe.pdf** file supplied in the program file. More detailed installation instructions are included in the user's manual.

8.1 ADORE Installation

Make files are provided in Disk2 directory for easy installation of ADORE for both the Intel and Lahey compilers on 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 files may be appropriately edited and used for ADORE installation.

8.2 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. In fact, the jar files supplied in the Disk4 directory under the Windows and Macintosh subdirectories are identical.

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

9. Contact Information

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

Dr. Pradeep K. Gupta
PKG Inc.
117 Southbury Road
Clifton Park, NY 12065-7714
USA
Phone: 518-383-1167
Web: www.PradeepKGuptaInc.com
Email: guptap@PradeepKGuptaInc.com