ADORE Update Version 9.10

Release Date: April 14, 2023

In terms of ADORE capabilities this enhancement to the last version 9.00 is relatively minor, although the amount of technical effort and resulting improvements in code architecture are significant.

1. Code Enhancements

Race Crowning in Roller Bearings: With increasing use of ceramic rolling elements the demand for effective race crowning has increased over the past 2 to 3 years. Although ADORE does permit arbitrary roller and race profiles in user programmable subroutines, this enhancement now permits race crowning in terms of simple geometrical inputs in the roller bearing input data. Thus, the data on input records 5B.2 and 5D.2 for cylindrical and tapered roller bearings are now fully implemented. As a part of this update, the computation of roller crown drop is implemented in a dedicated external procedure with significantly higher precision. With this higher precision, although the cylindrical roller bearing results were unaffected, a small insignificant change in tapered roller bearing solutions is observed. Overall, with no crowning on race surfaces, there should be no change in the roller/race solutions. Therefore, the version 9.10 test cases should compare well with those supplied with version 9.00, except for the tapered roller bearing solutions where there is a small but insignificant change in the solutions due to higher precision in computation of crown drop.

Please note that in the event a point contact is created by making both the race and rollers fully crowned, then for a geometrical compatible contact the roller to race contact angle becomes a variable, same as in ball bearings. Such a variability is presently not permitted while solving the equilibrium equations in roller bearings. Thus, a diagnostic message is printed when the race equilibrium is turned on by setting the kFS flag on record 3.3 equal to 0 with full crown specified on both the roller and the interacting race. This condition may sometimes be circumvented by running under prescribed race displacement by setting the kFS flag to 1 and prescribing appropriate race displacement on Record 9.1.1. The roller equilibrium under such a circumstance is carried out under constant contact angle; which is an assumption but may not be unrealistic due to extremely small value of the contact angle.

With this race crowning enhancement and the flexibility in roller geometrical imperfections it is now possible to have both point and line contacts in a roller bearing. Thus, the type of contact at each roller race contact is now identified in the print output. Also, the data structure in the fatigue life code module is appropriately modified such that both point and line contact constants are available in active memory stack. This permits realistic contact life computation based on the current contact type. ADORE uses a contact type variable to identify the contact type. These codes are defined in table 1.

In the event the user programmable routine is used to prescribe either the roller or the race surface, then the contact type defaults to the standard line contact (contact code =1) in cylindrical and tapered roller bearings.

Race Flexibility: Race flexibility was implemented in ADORE many years ago. However, due to numerical problems associated with step sizing and related truncation error this

option was subsequently suspended. As a part of the current effort this problem was revisited. After extensive numerical effort it was concluded that although the deformed shape of races could be successfully implemented in equilibrium solutions, the flexing frequency complicates the step sizing algorithm and the permissible step size becomes increasing small. A similar argument may also apply to cage flexibility. Also, in true sense the basic differential equations of motion, as formulated in ADORE, are truly applicable to rigid body dynamics where each bearing elements moves as a whole with fixed mass, moment of inertia and shift between the mass and geometric centers. In view of these difficulties and uncertainties it was decided to take the race flexibility option permanently out of ADORE and maintain ADORE as a truly rigid body dynamics tool. However, any geometrical change in race and/or cage geometries may still be implemented via user programmable subroutines; the assumption, of course, is that the inertial properties of the races (mass, moment of inertia, orientation of principal axes of inertia and the position vector locating the geometric center relative to the mass center) are still constant and the base rigid body equations of motion are valid.

Table1: Contact Type Definition in Cylindrical and Tapered roller Bearings

Contact Code	**Description**
1	Conventional line contact where neither the roller nor the race have a defined crown radius
0	Point contact in ball and spherical roller bearings where the races have a groove curvature conforming to the ball
-1	Point contact in cylindrical and tapered roller bearings where the race surface is flat and the roller has a full crown
-2	Point contact in cylindrical and tapered roller bearings where the race surface has a full crown while the roller surface is flat
-3	Point contact in cylindrical and tapered roller bearings where both the roller and interacting race surfaces have a full crown

Fatigue Life Models Subroutines: The extensive enhancements in life models in ADORE have been implemented in pieces as a result of continuing developments over the last five years. Hence, the subroutine Adrf1, which implements the models, and the code segment in Adra1, which sets of the input data and model coefficients have become increasingly complicated to a point where any future enhancement becomes difficult and very time consuming. Thus, the life subroutine and related input data segments are rewritten to streamline the codes. Also, a number data structures, which were initially created in anticipation of future generalities are taken out to make the code simpler and more easily readable. Thus, this enhancement only improves the code architecture and there are no changes in results.

2. ADORE User Manual

The resulting modifications in the input data records, which are relatively minor, have not been implemented in the user manual and version 9.00 user manual in unchanged. For accurate preparation of input data please refer to the input facility, AdrInput, as discussed below. The user manual shall be updated at the time of next major release.

3. ADORE Input Facility, AdrInput

The input facility, **AdrInput**, has been updated to include all changes to the input data as discussed above. In particular, please note the following:

- The kRaceFlex option on input data record 3.2 is eliminated.
- Records 8.6.1 to 8.6.3, corresponding to optional fatigue life modeling data, turned on by setting kLifeCons=1 on record 3.3, have been consolidated to just one record 8.6.1 to contain only the load/stress capacity constant modifiers for the races and rolling elements. All the failure shear stress and depth exponents are now hard coded in Adra1 in the internal procedure LifeConstants. Records 8.6.4, 8.6.5 and 8.6.6 are now renamed as 8.6.2, 8.6.3 and 8.6.4.

For conversion of version 9.00 input data files to the version 9.10 data file, please open the data.txt file in AdrInput and examine Record 3.2 and 3.3 carefully. Since kRaceFlex option is no longer there, the total number of data values on Record 3.2 are reduced by one. Therefore, check each value on Record 3.2 and make sure that the data values are correct. In the event the optional fatigue life data is turned on by setting kLifeCons=1 o Record 3.3, then examine Records 8.6.0 and 8.6.1. If arbitrary rolling element material is selected by setting kReMat=1 on Record 3.3 then examine Record 8.6.2. In the event arbitrary outer race material is selected by setting kRaceMat1=1 on record 3.3 then examine Record 8.6.3. Likewise, if arbitrary inner race material is selected by setting kRaceMat2=1 on Record 3.3, then examine Record 8.6.4. Also note that the earlier records 8.6.5 and 8.6.6, if present in the old data, will now be read in as subsequent records in the new data file. Thus, proceed to examine each of the subsequent data record and make sure that all data values conform to the desired inputs.

4. ADORE Plot Facility, AdrPlot

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

5. ADORE Animation Facility, AGORE

There are no updates to **AGORE** in this version.

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 **Adore910.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