ADORE Update Version 5.30

Release Date: September 12, 2006

ADORE 5.30 is basically a compilation of temporary fixes issued over the year in versions 5.21, 5.22, 5.23 and 5.24. All these enhancements and fixes are now made permanent in version 5.30.

Program Enhancements

Truncation Checks and Simulation over Large Number of Time Steps

This enhancement is prompted by increasing use of ADORE for bearing performance simulation over thousand of time steps. When doing computations over large number of time steps, a careful control over the local truncation error is essential, although the explicit integration procedures used are inherently stable. This is particularly true when the bearing is on a verge of instability. The truncation check procedures are therefore modified to maintain increased accuracy over large number of time steps. In order for this enhancement to work efficiently it is suggested that the truncation limit on Record 2.1 be set to 1.0E-06 when stability of the solutions is a concern over large number of time steps.

Traction at Rolling Element to Race Contacts

Rolling element to race traction has been known to be one of the key parameters which control cage stability, skidding and overall bearing performance. While the print output gives maximum slip velocity and pertinent traction coefficient, it has been difficult to envision a traction curve which may be applicable at the pertinent operating conditions. To enhance the understanding and provide insight into rolling element to race traction the operating traction curve for the heaviest loaded rolling element is now included in the print output. This data may be viewed along with the max slip and slip distribution output to determine the extent of operation on the negative slope of the traction curve. This provides significant guidance with regard to the onset of instability.

Quasi-Static Solutions

Equilibrium equations in the quasi-static module are now modified to include the Corioliss and transport acceleration terms corresponding to moving reference frames, such as in planetary gear applications. Thus ADORE may now be used with mode=1 for bearing subjected to planetary motion or other applications where the base bearing frame moves in space.

In addition to the above, the quasi-static output is modified to make it more compatible with earlier versions of ADORE. The modifications basically resulted in adding more variables to the output list.

Rectified problem in computing stiffness for cylindrical roller bearings. The modifications consists of elimination of axial stiffness loop and setting symmetrical load distribution solutions.

Initial Conditions for Cage Motion

Since for most bearings it has been fairly well documented that under most stable conditions the cage whirl velocity is equal to its angular velocity and the cage whirls in a fairly circular orbit, cage motion with purely circular whirl was set as initial condition in ADORE versions 4.1 and higher. At the time it was speculated that if the cage interactions are superimposed on such a

stable motion a steady-state cage motion may be reached in greatly reduced number of steps. Also, in the event of any instability the motion resulting from excessive cage interactions will be more significant in comparison to the initial circular whirl motion. However, since, there is really no applied force sustaining the initial whirl, the implementation of such a such a motion was truly an assumption based on certain experimental evidence.

Over the past few years after modeling a variety of applications it is found that with the above initial conditions, the cage interactions are greatly reduced at least during the early transients and for some applications the time required to reach steady-state is greatly increased. Furthermore, the steady-state cage whirl has demonstrated certain dependence on the initial conditions. Based on these observations, the assumption of initial circular whirl, first introduced in version 4.1 is now withdrawn. The cage mass center velocity, corresponding to the initial whirl velocity, is now reset as simple translational velocity as done in versions earlier than 4.1. It is speculated that although the steady-state circular whirl, if and when it exists, may take a longer time to reach, cage instabilities, when they exist, may be more rapidly identified. Since there is no applied force required under such conditions, such a specification is consistent with equations of motion and free from any assumptions.

Cage whirl in comparison to rotation about the mass center can be immediately visualized by closely examining the animated 2D cage motion provided by the animation code, AGORE, which is now also available for the Java platform.

The above update is only significant when bearing motion is simulated with initial non-zero whirl velocity of the cage.

Race Geometrical Imperfections

The input data for race geometrical imperfections is now documented in the print output under bearing geometry.

Code Corrections

1. While incorporating the visco-elastic model in version 5.20 the traction coefficients for the hypothetical traction model were not set correctly. This problem in now corrected.

2. While the ADORE input facility specifies race crown (a variable which is presently not used), ADORE variable list in the read statement does not include this variable in version 5.20. The affected input data records are 5B.2 and 5D.2 for cylindrical and tapered roller bearings respectively. This compatibility issue is corrected in the current version.

3. A component of the Jacobian matrix for a quasi-static solution for roller bearings is corrected. The affected component corresponds to moment equilibrium about the transverse (or skew) axis, which is rarely used. The correction only affects convergence.

Current Limitations

The following features, which were available in earlier version but were not commonly used, are still not available in version 5.30:

- Predictor-Corrector integration methods
- Race flexibility option

Users Interfaces

1. Changed max dimension of y-axis labels to 20 in DisplayPlot.java. This was to accommodate the max number of axis labels. which sometimes exceeded the earlier limit of 10.

2. In PlotData, changed the limits evaluation for orbit to axis #2 and #3, which correspond to y and z displacement. This was done to accommodate race whirl orbits, where the axial displacement is quite large.

3. Modified DisplayPlot to allow the graphic area to be user adjustable by changing the window size. Also moved the buttons to right side of the window.

4. Modified PlotData to correctly set dataCode when the file is not opened. This eliminates an error message generated in case of clicking the CANCEL button on the file open dialog.

5. Modified FileProcs to set the initial currDirec to the application default from where the application calling FileProcs is run.

6. Added setLocation(32,32) to both AdrInput and AdrPlot to offset the opening window from the top left corner of the screen.

7. Orbit plot size and problem with rewriting independent variable array xi was discovered. The problem is fixed by correcting the plot size variables, pltWidth and pltHeight in drawOrbitPlot. Also, a new array xj is introduced to preserve the independent variable data in array xi. The update affected java file DisplayPlot.java.

Test Cases

The normal ball and cylindrical roller bearing test cases are included with the program files; in addition to the input data print output files all plot data sets are included 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.

While comparing the results with those produced by earlier versions some differences in the transient solutions and time step sizes may be observed. These difference are primarily due to code corrections outlined above.

Program File Contents:

Due to a number of problems associated with transmission of zip and tar files over the internet, the scheduled 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. Temporary fixes during the subscription period of annual ADORE update service shall continue to be distributed electronically as needed.

The media may contain up to four subdirectories as listed below:

Disk1

Update53.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 containing detailed instructions for program installation and use.

Ball:

Subdirectory containing ball bearing test case

Roller:

Subdirectory containing roller bearing test case

Disk2

***.f files:**

ADORE FORTRAN-90 source files

Makefile:

Make file to create ADORE executable on IBM AIX systems

Disk3

Supplied only with license to optional Java facilities.

adrJavFacDoc.pdf:

User instructions for installation of Java input and plot facilities, adrInput and adrPlot.

setup.bat:

Setup batch file to compile adrInput and adrPlot on Windows system.

adrInput.bat:

Batch file to execute adrInput

adrPlot.bat:

Batch file to execute adrPlot

***.java:**

Java source codes for adrInput and AdrPlot.

Disk4

Supplied only with license to optional graphic animation facility AGORE.

AgoreNotes.pdf:

Notes and installation instructions for animation facility AGORE.

Agore.bat:

Batch file to execute AGORE.

setup.bat:

Setup batch file to compile and install AGORE on Windows System.

***.java:**

Java source files for animation facility AGORE.

Program Installation

The installation procedure presented below is primarily for IBM RS/6000 system, operating under the AIX 4.3 operating system. For other systems appropriate changes to the compilation command will have to be made.

ADORE:

Installation of ADORE is simply accomplished by executing the makefile supplied in the Adore source directory. Copy all files from the Disk2 directory to appropriate directory on the hard disk and then, on an IBM system, issue the command:

./make

This will create an executable file adore, which could be installed in appropriate directory consistent with the user environment.

On non-IBM system, simply edit the make file to include appropriate compiler command instead of the xlf90 used on IBM system. Note that the option -c and -qmixed respectively mean that at this step perform compilation only, and that the variable names use mixed (both lower and upper case) characters. The option -qmixed is not absolutely essential for program operation; it is convenient during program development and debugging.

On the Windows system, if the Microsoft Developer Studio is used to create the executable, the following suggested procedure may be helpful.

1. Start Microsoft Developer Studio and select the File option to create a new project.

2. For type of application, select “Console Application” and name the application as adore51 or other desired name.

3. Once the project space is created, use the inert option to add source files. After navigating to the appropriate source directory, first add the file m_parameters.f only. In the second step add all the m_*.f module files. In the final step all the other source file. The file to be added is simply selected by a mouse click on the file in the selection widow. To select more than one file, simple hold the Ctrl key while clicking the mouse.

4. Now use the Build option to create the executable.

Java facilities adrInput and adrPlot

See instructions and setup files in subdirectory Disk3.

AGORE

See instructions in file AgoreNotes.pdf in Disk4 subdirectory.

Contact Information

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

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