

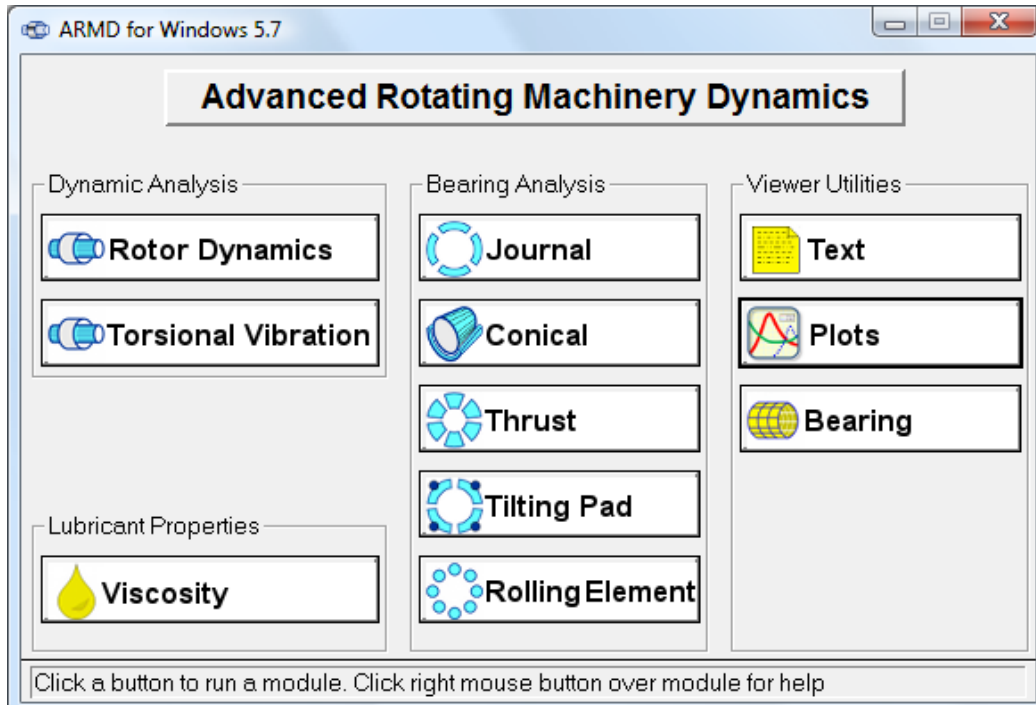
**New  
Release**

# Advanced Rotating Machinery Dynamics

# ARMD™ Version **5.7G2**

THE COMPLETE SOFTWARE PACKAGE FOR

- **Rotor Dynamics**
- **Torsional Vibration**
- **Fluid-Film Bearings**
- **Rolling-Element Bearings**
- **Lubricant Analysis**



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# ARMD<sup>TM</sup>

Version **5.7G2** for Windows

## Advanced Rotating Machinery Dynamics

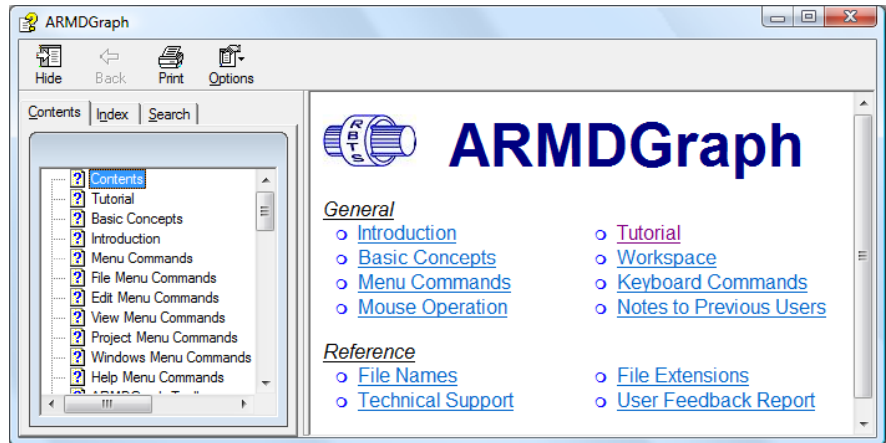
*The Worldwide Leader in Software for Rotating Machinery*

*Design, Analysis, Performance Predictions and Troubleshooting*

Brief summary of new & improved features in ARMD V5.7:

### New Features

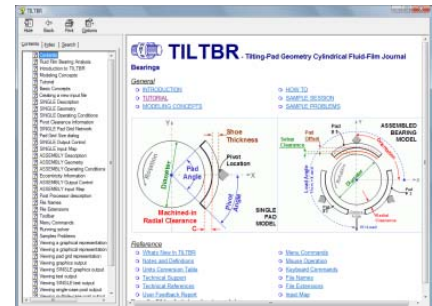
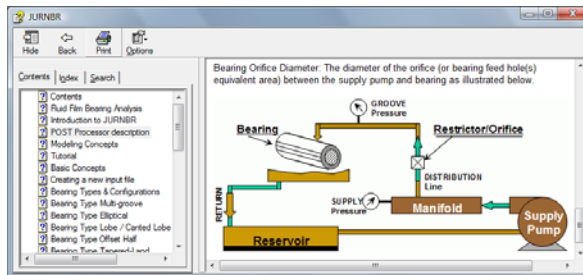
- ▶ **ARMDGraph** is a newly developed utility for graphing ARMD results in two dimensional (X-Y) plots with full user control to line types, color, thickness, symbols, scales, grids, etc. It includes features for annotations and line markers all of which can be saved in a Workspace for use with



single or multiple files. Implemented Workspace feature is intended to save settings in templates for use with existing or future generated graphic output files.

- ▶ **Major** architecture overhaul and modifications, including files/folders allocation for installation and operation on Vista, Windows 7 operating systems (OS), utilizing OS security & ARMD installation in protected and public areas/folders.

- ▶ Help utility with enhanced content and navigation.



- ▶ Increased fluid-film bearing modules capabilities including number of pads, cases, auto-scroll through multiple cases, grids for specified pressures, eccentricities, and others.
- ▶ Tilting pad bearings individual pads temperature, flow, and power for **flooded** and **direct feed** lubrication systems.
- ▶ Thrust bearing simulation results to include side leakage flow rates at inner/outer edges.
- ▶ Fixed geometry bearings, user specified groove angle, for non-uniform pad distribution.

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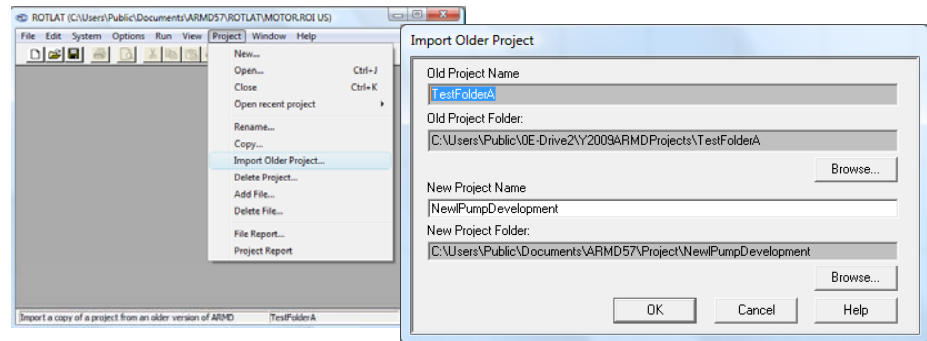
## Advanced Rotating Machinery Dynamics

*The Worldwide Leader in Software for Rotating Machinery*  
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Brief summary of new & improved features in ARMD V5.7:

### New Features

- ▶ Project migration tools to import projects & folders from previous versions to version 5.7.



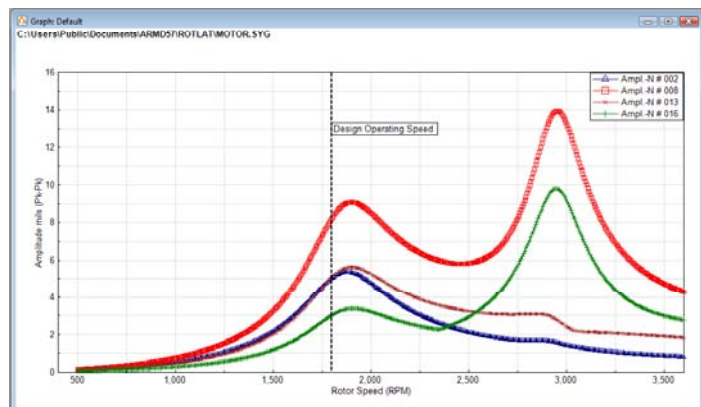
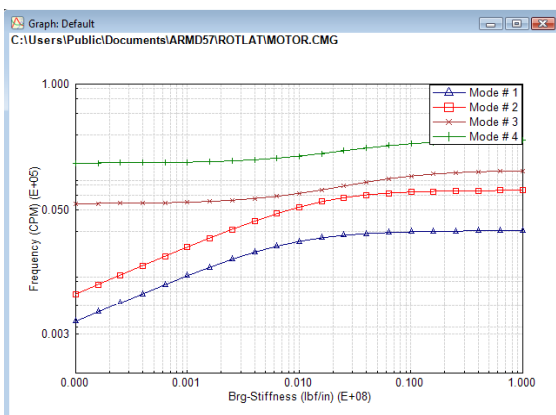
- ▶ Rotor dynamics simulation with **dynamic** (frequency dependent) bearing support mass, stiffness, and damping characteristics.

No. of Frequency Bands	Dynamic Coefficients	Description
1	5	1st Set of Dynamic K's 0-5000 cp
2	5	2nd Set of Dynamic K's 0-5000 cp

Minimum Frequency	Maximum Frequency	Weight X	Stiffness X	Damping X	Weight Y	Stiffness Y	Damping Y	Description
1.8000E+003	2.0000E+003	7.0648E+005	1.8977E+008	2.8190E+004	3.0686E+005	4.1301E+007	2.4540E+003	2nd St
2.0000E+003	2.2000E+003	7.0648E+005	1.8977E+008	2.8190E+004	8.6796E+005	2.2473E+008	1.7514E+004	3rd Se
2.4000E+003	2.6000E+003	7.0648E+005	1.8977E+008	2.8190E+004	8.6796E+005	2.2473E+008	1.7514E+004	4th Se
2.6000E+003	2.8000E+003	7.0648E+005	1.8977E+008	2.8190E+004	8.6796E+005	2.2473E+008	1.7514E+004	5th Se
2.8000E+003	3.0000E+003	7.0648E+005	1.8977E+008	2.8190E+004	3.7702E+006	1.2979E+009	4.8042E+004	6th Se

- ▶ Rotor dynamic simulation with user specified individual bearing support flexibilities.
- ▶ Increased simulation points for critical speed map generation.
- ▶ Increased (user specified) simulation points for rotor unbalance response analyses.



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## Advanced Rotating Machinery Dynamics

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Brief summary of new & improved features in ARMD V5.7:

### New Features

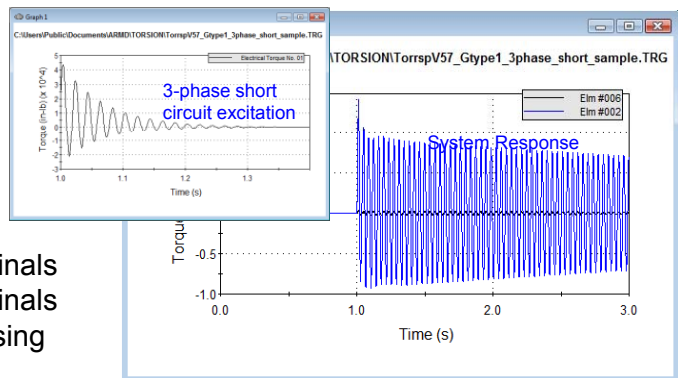
- ▶ Torsional Vibration: **Electrically induced** (time-varying) **exciting** torques associated with generator and induction motor operation incorporated into time-transient response simulation module (TORRSP). These torques *include*:

#### Generator

- Type 1: 3-phase short circuit
- Type 2: Line-to-Line short circuit
- Type 3: False coupling short circuit

#### Induction Motor

- Type 4: Start from standstill  
(a.k.a. Across the line)
- Type 5: 3-phase short circuit at terminals
- Type 6: 2-phase short circuit at terminals
- Type 7: High-speed automatic reclosing



- ▶ Torsional Vibration: **User defined** CSV torque table representing time-varying exciting torque at any location along the drive train (e.g. simulation of clutch engagement).

### Enhanced/Improved Features

- ▶ Increased number of stations from 250 to **500** in rotor-dynamics/torsional modules.
- ▶ Increased number of pads from 40 to **100** in bearing modules.
- ▶ Increased number of cases from 100 to **200** in bearing modules post-processors.
- ▶ Fluid-film bearing wizards with improved default settings and graphical illustration of many commonly used bearings in industry.
- ▶ Enhanced presentation of English/Metric units notation throughout the package.
- ▶ Backward compatible with previous versions of ARMD input file formats.
- ▶ Significant enhancements in solvers for efficiency, settings, error reporting, etc.
- ▶ ARMD projects can be created under user-specified folders and on any drive.
- ▶ Supports Microsoft Windows **2000**, **XP**, **Vista**, and **Windows 7** (32 and 64 bit versions).

# ARMD<sup>TM</sup>

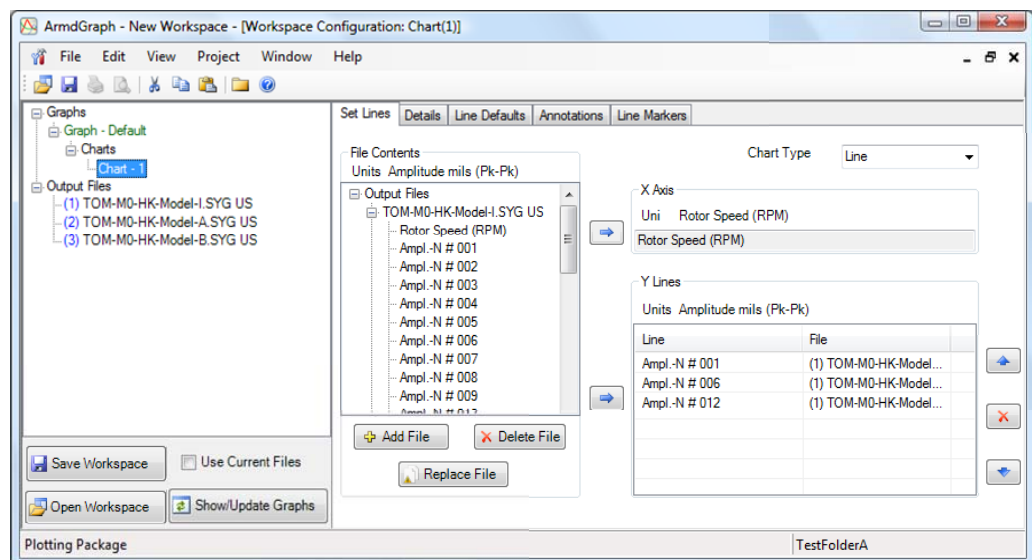
Version **5.7G2** for Windows

## Advanced Rotating Machinery Dynamics

### [New Graphics Utility \(ARMDGraph\)](#)

ARMDGraph is a new graphics utility that employs a Workspace concept to manage multiple graphs with associations to single or multiple graphics output files. The workspace environment contains all user defined plot/chart configuration settings for graphics output files generated by

ARMD solvers. The workspace configuration form consists of two panels. The left panel contains a tree view of the graphs, charts, and graphic output files. The right panel contains all chart/graph settings.

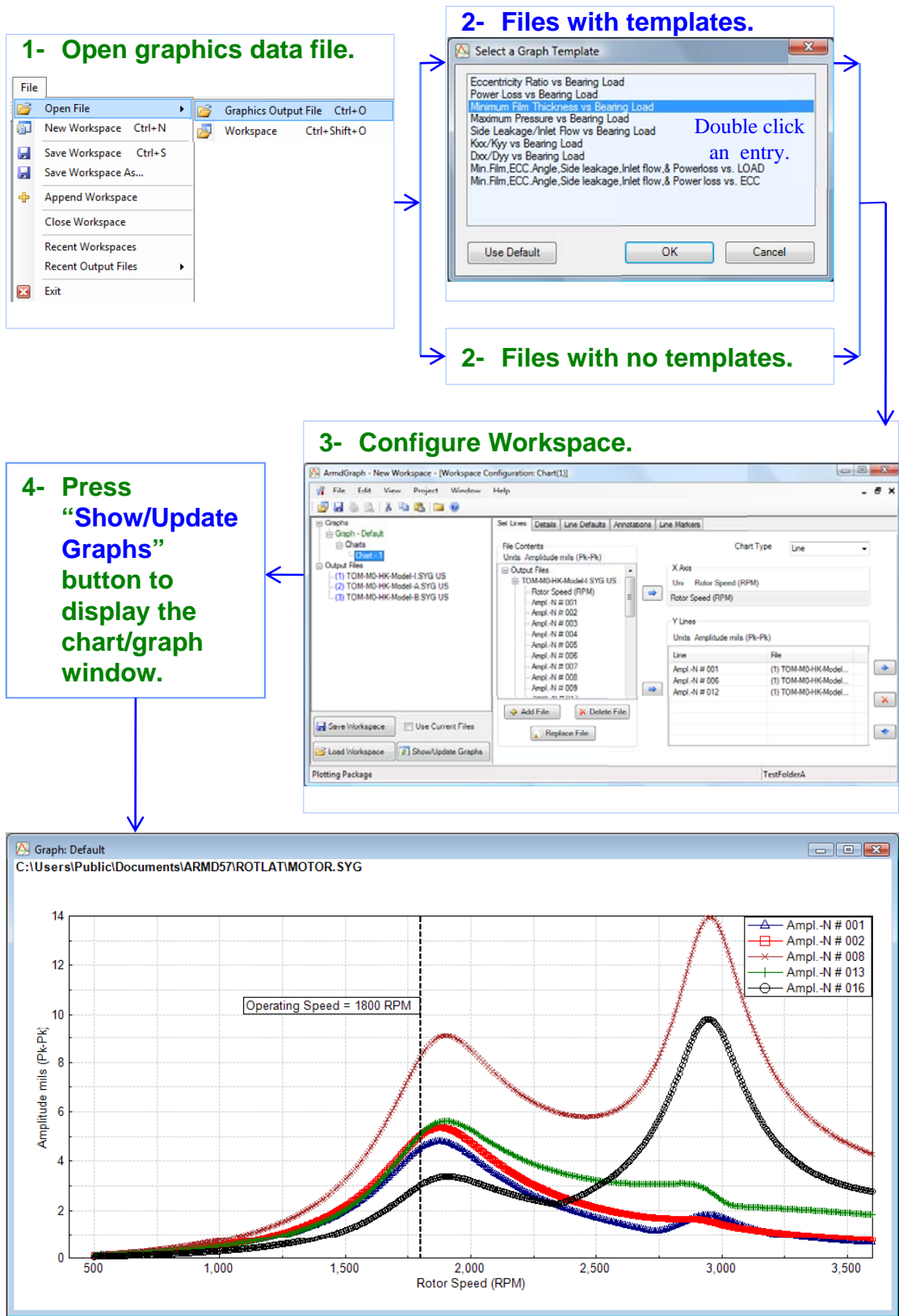


ARMDGraph features include:

- Workspace concept that contains all graph settings and linked graphics output files in one form customized by the user.
- Existing workspace can be easily applied to newly generated graphics output files.
- New graphical user interface to access and customize graphs.
- New file format (\*.usrx) allows more customization of graphics data than previous (\*.usr) format.
- Ability to create multiple graphs each of which may contain multiple charts.
- Ability to plot from two or more graphics output files.
- Backwards compatible with files generated by RBTSGRAF (\*.usr) graphing utility.
- Customizable annotations and line markers.
- Automatic detection of graphics data file changes/updates.
- Plots can be rotated and copied to the clip board as bitmaps or enhanced metafiles.
- Utilizes GUI help system.
- Accelerator keys for accessing menu items and switching between charts.
- Multiple plots per window (1, 2, 3 or 4), line, polar and FFT plots.
- Templates for automatic configuration of graphs.
- Save/restore user options (\*.USRX), for custom graphs, including:
  - Log, semi-log or linear axis scaling.
  - Automatic or manual axis scaling.
  - Grid lines (ON or OFF).
  - Legend position (hidden, inside or outside right).
  - Draw curves with lines, symbols or both.
  - Macro strings for flexible title assignment.

## New Graphics Utility (ARMDGraph)

With ARMDGraph, in few simple steps a workspace can be setup, saved and a graphical representation of simulation results from ARMD solvers can be generated as illustrated below .



# ARM D<sup>TM</sup> Version 5.7G2 for Windows

## Advanced Rotating Machinery Dynamics

### Rotor Dynamics (ROTLAT)

- ▶ New computation of system rotor dynamics with consideration of **static** or **dynamic** (frequency-dependent) bearing supports/pedestal mass, stiffness, and damping characteristics have been incorporated in all ROTLAT solvers.

Station	DOF	Type	Auto	ND File	Elevation	Static Pedestal	Dynamic Pedestal
1	2	2	<input type="checkbox"/>	Manual	0.000000E+000	1	1
2	20	2	<input type="checkbox"/>	Manual	0.000000E+000	2	2

Dynamic pedestal id	No. of Frequency Bands	Dynamic Coefficients	Description
1	5	Edit...	1st Set of Dynamic K's 0-5000 cp

Minimum Frequency	Maximum Frequency	Weight X	Stiffness X	Damping X	Weight Y	Stiffness Y	Damping Y
1	0.0000E+000	1.0000E+002	5.0000E+005	0.0000E+000	1.0000E+002	5.0000E+005	0.0000E+000
2	1.0000E+003	2.0000E+003	1.0000E+002	5.0000E+005	0.0000E+000	1.0000E+002	5.0000E+005
3	2.0000E+003	3.0000E+003	1.0000E+002	5.0000E+005	0.0000E+000	1.0000E+002	5.0000E+005
4	3.0000E+003	4.0000E+003	1.0000E+002	5.0000E+005	0.0000E+000	1.0000E+002	5.0000E+005
5	4.0000E+003	5.0000E+003	1.0000E+002	5.0000E+005	0.0000E+000	1.0000E+002	5.0000E+005

Features/Output Control

Number of mode shapes to plot (ROSTAB only):

Number of speed increments (ROSYNC only):

Gravitational body force factors

X direction:

Y direction:

Pedestal/housing considered

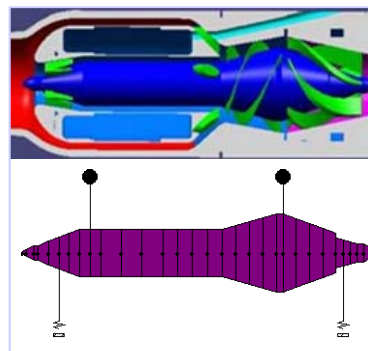
Static pedestal mass, stiffness and damping

Dynamic (frequency-dependent) pedestal mass, stiffness and damping

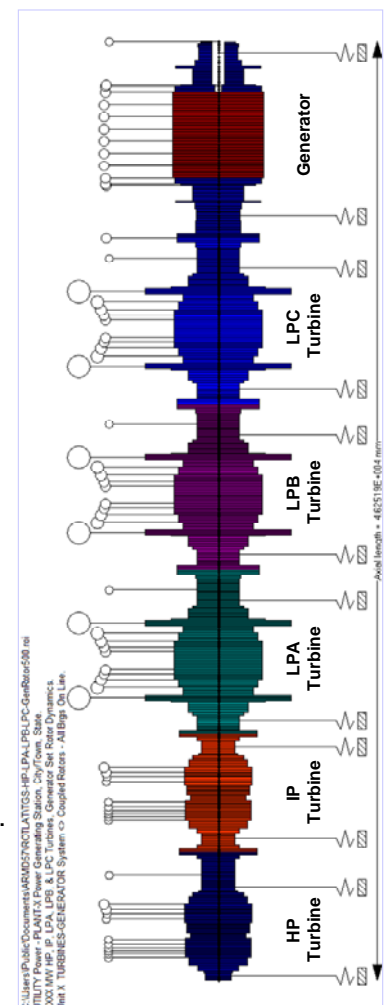
OK Cancel Help

- ▶ Static and dynamic (frequency dependent) bearing support/pedestal characteristics data are maintained when feature is disabled/enabled.

- ▶ Increased capacities: **100** bearings with 42 DOF each, 40 speeds, 40 external forces, 100 materials, **100** mode shapes, and **500** stations. Permitting the modeling and analyses of rotating systems as small as infant size heart pumps to large size electric power generation units.



- ▶ Disc graphical presentation is scaled to disk inertia ( $wr^2$ ) values.
- ▶ Increased simulation points (large stiffness range can be specified) for critical speed map generation and for improved graphical map presentation.
- ▶ Increased (user specified) simulation points for rotor unbalance response analyses.

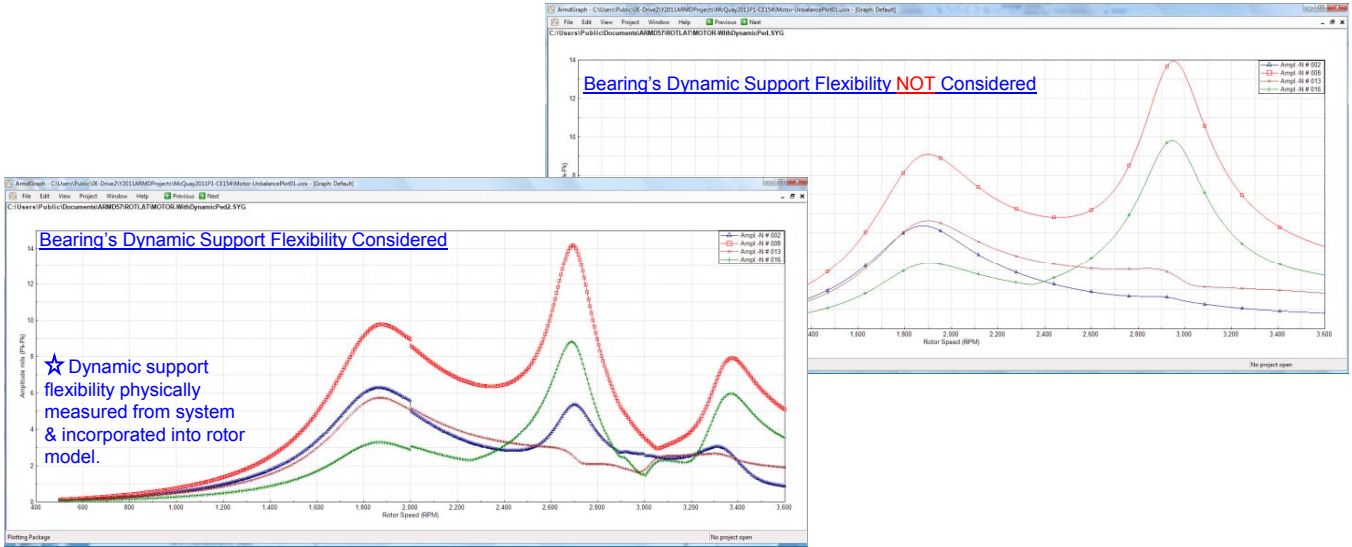


# ARMID<sup>TM</sup> Version 5.7G2 for Windows

## Advanced Rotating Machinery Dynamics

### Rotor Dynamics (ROT LAT)

- Modifications to ROTLAT user interface and solvers for rotor dynamic simulations considering selected (not all) bearing's support flexibilities.



- Element summary feature calculates summations of weight and inertia for selected shaft element(s). Summary also includes totals of combined shaft/disc weight s and inertia values.

TP	MT	R	Length	OD1	ID1	OD2	ID2	Name
5	1	1	9.00000E-001	3.93820E+000	0.00000E+000	0.00000E+000	0.00000E+000	E to G Roller Bearing Center
6	1	1	7.95000E-001	3.93820E+000	0.00000E+000	0.00000E+000	0.00000E+000	G to J Step in Shaft
7	1	1	2.50000E+000	5.00000E+000	0.00000E+000	0.00000E+000	0.00000E+000	J to K S
8	1	1	2.00000E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	K to M S
9	1	1	2.00000E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	K to M S
10	1	1	2.00000E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	K to M S
11	1	1	1.64350E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	K to M S
12	1	1	1.64350E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	K to M S
13	1	1	2.00000E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	K to M S
14	1	1	2.00000E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	K to M S
15	1	1	2.00000E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	K to M S
16	1	1	1.00000E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	M to N S
17	1	2	2.12500E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	N to R R
18	1	2	2.12500E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	N to R R
19	1	2	2.12500E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	N to R R
20	1	2	2.12500E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	N to R R
21	1	2	2.12500E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	N to R R
22	1	2	2.12500E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	N to R R
23	1	2	2.12500E+000	4.97000E+000	0.00000E+000	0.00000E+000	0.00000E+000	N to R R

**Element Selection Summary**

Shaft length = 1.289350E+001 in  
 Shaft weight = 1.406764E+002 lbf  
 Shaft inertia (WR<sup>2</sup>) = 8.635795E+002 lbf-in<sup>2</sup>

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Total weight = 3.386764E+002 lbf (Shaft & Disc)  
 Total inertia (WR<sup>2</sup>) = 7.163580E+003 lbf-in<sup>2</sup> (Shaft & Disc)

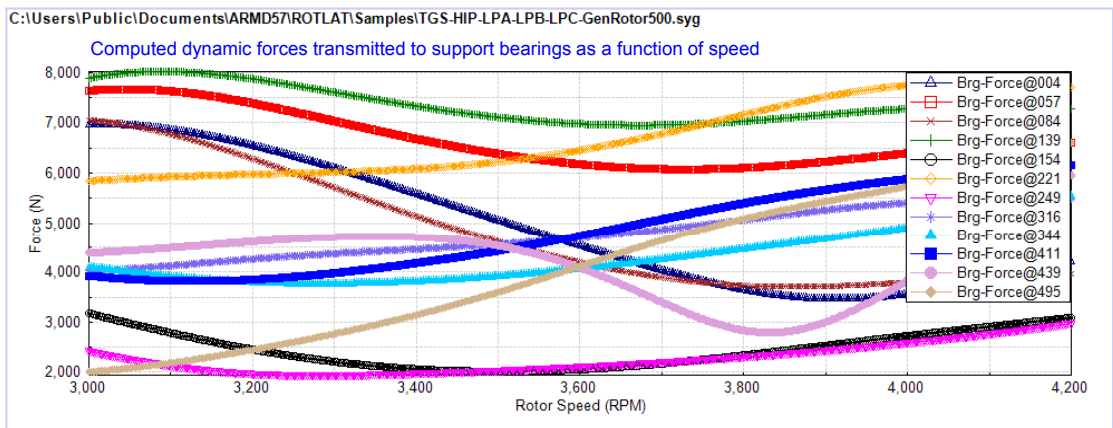
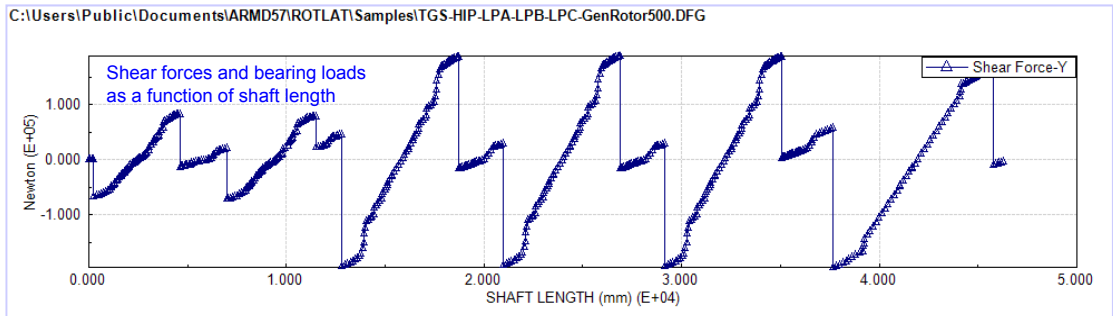
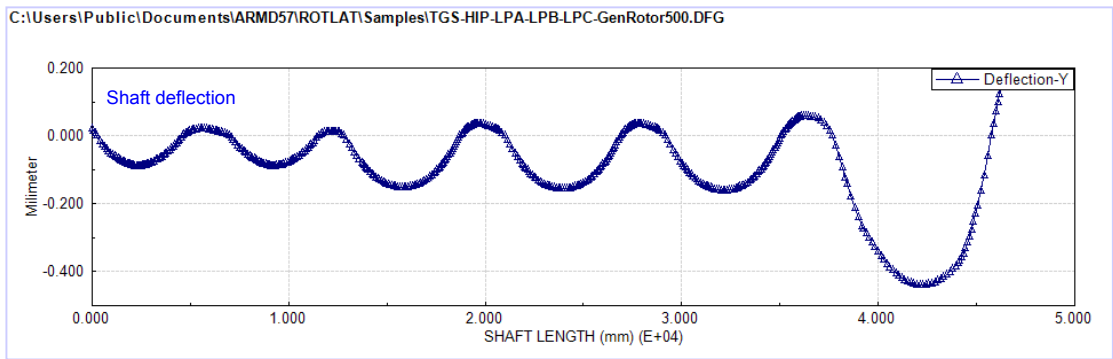
OK

# ARMD<sup>TM</sup> Version 5.7G2 for Windows

## Advanced Rotating Machinery Dynamics

### Rotor Dynamics (ROT LAT)

- ▶ Integrated simulation for computing static and dynamic forces transmitted to bearings and foundation for complex systems. All results can be combined in one ARMDGraph workspace with user settings for presentation of multiple graphs and/or multiple windows containing multiple graphs.



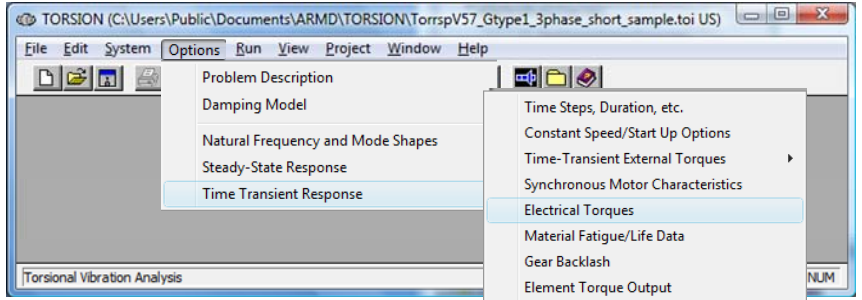
- ▶ Numerous modifications to solvers and user interface for improved performance, error reporting/diagnostics, default setting, efficiency, and round off accuracy.

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## Advanced Rotating Machinery Dynamics

### Torsional Vibration (TORSION)

- ▶ New features incorporated in TORSION module to consider electrically induced (time-varying) exciting torques associated with generator and induction motor operation that include:

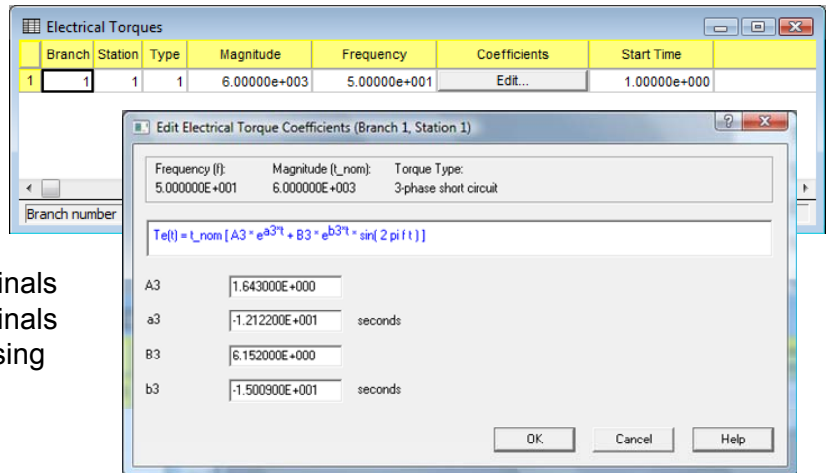


#### Generator

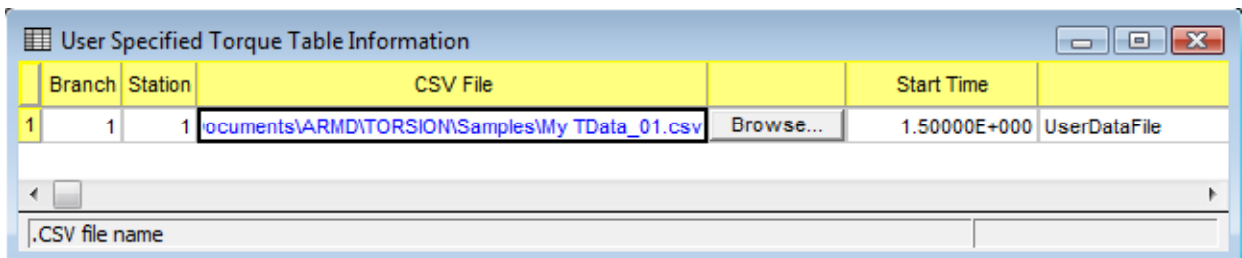
- 1: 3-phase short circuit
- 2: Line-to-Line short circuit
- 3: False coupling short circuit

#### Induction Motor

- 4: Start from standstill
- 5: 3-phase short circuit at terminals
- 6: 2-phase short circuit at terminals
- 7: High-speed automatic reclosing



- ▶ Increased capacities: **100** materials, **100** mode shapes, **500** stations, 100 springs/bearings.
- ▶ User defined time-varying exciting torque can be specified in CSV torque table file. This feature can be used to define any type of time-varying torque function at any location along the drive train.



- ▶ Electrical excitation, synchronous motor torque, user specified time transient external torques, & calculated system response torques are available in the graphics output file.
- ▶ Numerous modifications to solvers and user interface for improved performance, error reporting/diagnostics, default setting, efficiency, and round off accuracy.

# ARMID™

Version **5.7G2** for Windows

## Advanced Rotating Machinery Dynamics

### Bearings (Fluid-Film)

- ▶ New algorithm in tilting pad bearings module for performing individual pad heat balance to compute pad temperature, flow, and power calculations for **flooded** and **direct feed** lubrication systems.
- ▶ New modifications to tilting pad bearing module for optional user configuration of tilting pads with sprag relief (machined taper at leading & trailing edges of pad).
- ▶ Addition of Auto 100 eccentricity-ratios/clearances to all modules for enhanced calculations and results.
- ▶ Increased fluid film bearing modules capabilities: 40 to 100 pads, 100 to 200 cases in post-processors, 1,000 to 25,000 pressure grid points, auto-scroll through multiple cases in post processors, & user specified groove angle for non-uniform pad distribution and unique configurations.
- ▶ Thrust bearing inner/outer diameter side leakage flow results in single case post processor.
- ▶ *Improved* tapered-land bearing configuration handling between main user interface, post-processors, and 3-D view simulation in JURNBR and HYBCBR modules.
- ▶ *Improved* default settings in all bearing templates and enhanced wizard functionality.
- ▶ *Improved* lubricant feeding system & chamfer flow calculations including turbulence effects in all modules.

**TIL-POST (C:\Users\Public\Documents\ARMID57\TILTBR\5Pad-LoadBetweenPads.tpi)**

Heading  
5-PAD TILTING PAD BEARING Modeled with 60 Deg.Pad.Arc CENTRALLY PIVOTED  
LOAD-BETWEEN-PADS WITH PAD PIVOT LOCATION AT 90 DEGREE FROM +X AXIS.  
D=90mm, L=40mm, C=0.150mm, Preload=20%

Diameter: 9.000000E+001    Length: 4.000000E+001    # Pivot Clearances: 50  
Pad Angle: 6.000000E+001    Piv. Angle: 3.000000E+001    Viscosity: 9.692554E-003  
Clearance: 1.500000E-001    Rotational: 8.500000E+003

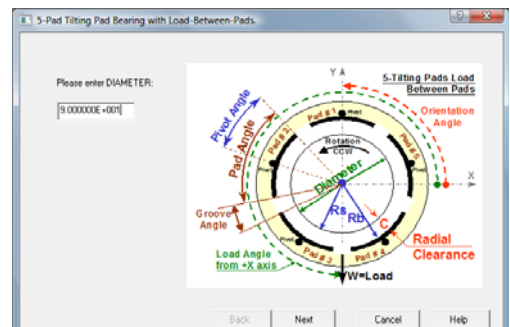
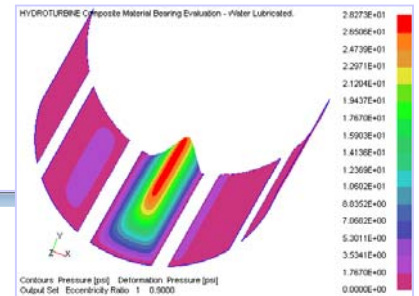
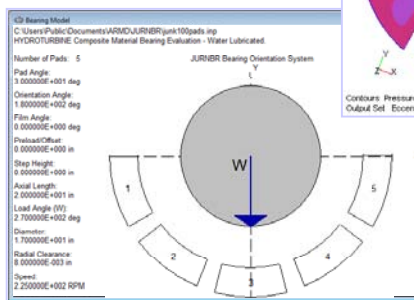
Ort. Angle: 9.000000E+001    Grv. Angle: 0.000000E+000    Load Angle: 2.700000E+002  
Clearance: 1.500000E-001    Load: 2.300000E+003    Preload: 2.000000E-001  
Speed: 8.500000E+003    Viscosity: 0.000000E+000    Gamma: 0.000000E+000

Case 1 of 1    No. of pads: 5     Full Matrix    3-D View

Min. Film Thick. --> 4.0492E-02 (mm) | ECC = 0.7344 @ Angle = 270.00 (Deg)  
Power-Loss ---> 1.7943E+03 (Watt) | Side-Leakage QF -> 2.5250E+00 (L/min)  
Load Capacity --> 2.2980E+03 Newton | Inlet-Flow QI -> -2.0573E+01 (L/min)

Supply-Oil Temp > 44.999 (Deg C.) |>>> STIFFNESS (Newton/Meter)

Pad No.	Sump/Groove Temperature (degree C.)	Avg-Film Temperature (degree C.)	Max-Film Temperature (degree C.)	Min-Film Thickness (mm)	Power Loss (watt)	Side Leakage (L/m)
1	6.7235E+01	6.7685E+01	6.8135E+01	1.4994E-01	1.9410E+02	3.1971E-03
2	6.7235E+01	6.7701E+01	6.8168E+01	1.4285E-01	1.9775E+02	2.5869E-01
3	6.7235E+01	7.1167E+01	7.5100E+01	4.0492E-02	6.0233E+02	1.0038E+00
4	6.7235E+01	7.1167E+01	7.5100E+01	4.0492E-02	6.0233E+02	1.0038E+00
5	6.7235E+01	6.7701E+01	6.8168E+01	1.4285E-01	1.9775E+02	2.5869E-01



**Many more...**