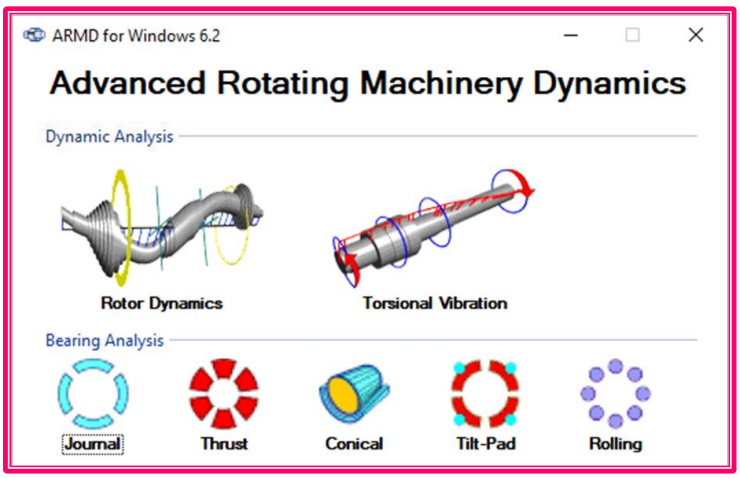
Advanced Rotating Machinery Dynamics

PACKAGES Version 6.2

New Release

ARMD Packages: Detailed Information

- **ROTOR DYNAMICS** (ROTLAT)
  - **Stability Analysis** (ROSTAB)
  - **Unbalance Response** (ROSYNC)
  - **Steady State Response** (ROSSRP)
  - **Time Transient Response** (RORESP)
  - **Critical Speed & Stability Maps** (ROTORMAP)
- **TORSIONAL VIBRATION** (TORSION)
  - **Natural Frequencies & Mode Shapes** (TORNAT)
  - **Steady State Response** (TORHRM)
  - **Time Transient Response** (TORRSP)



- **FLUID-FILM**
  - **Fixed Geometry Journal**
  - **Fixed Geometry Conical**
  - **Tilting-Pad Geometry Journal**
  - **Fixed & Tilting-Pad Geometries Thrust**

Please contact ***Dr. Andreas Laschet*** as RBTS' consultant and representation for the regions **Europe, Middle East, Africa** with the following communication details:

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Rev:20230801

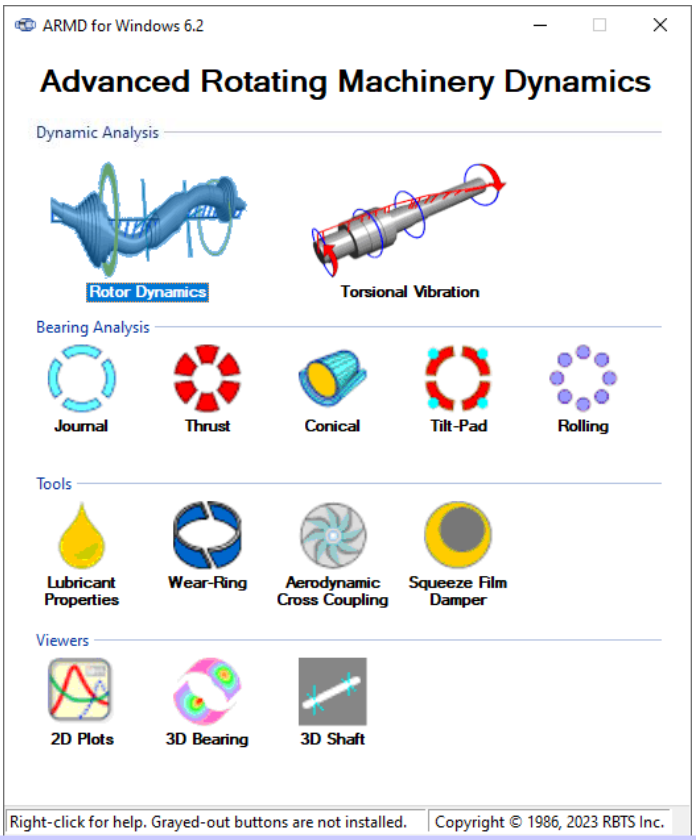
Advanced
Rotating
Machinery
Dynamics

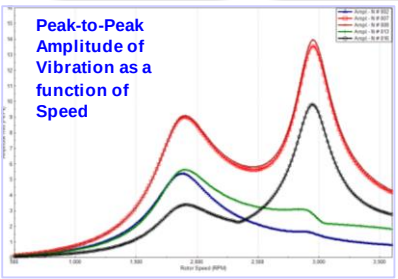
ROTLAT Version 6.2

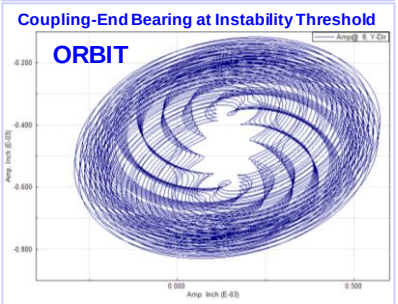
New Release

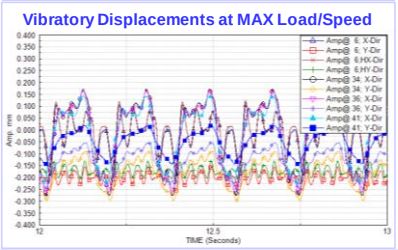
Rotor Dynamics – Rotor/Bearings/Supports Lateral Vibration Analysis

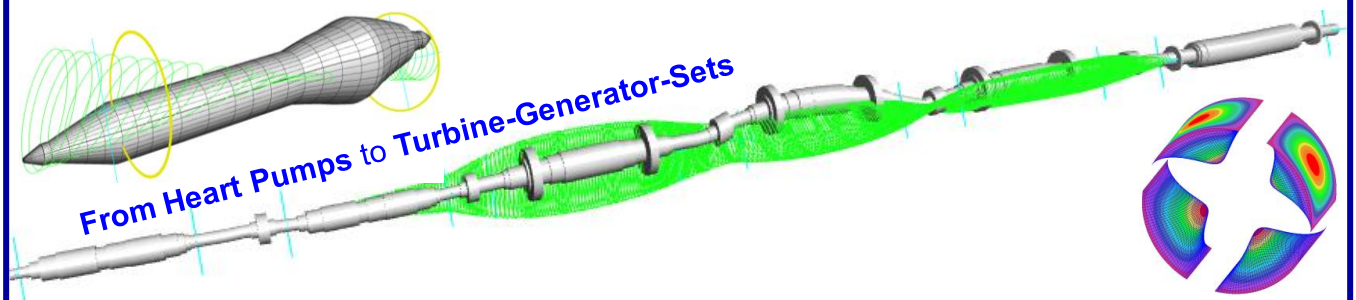
ROTOR DYNAMICS (ROTLAT) → **Stability Analysis** (ROSTAB) → **Unbalance Response** (ROSYNC) → **Steady State Response** (ROSSRP) → **Time Transient Response** (RORESP) → **Critical Speed & Stability Maps** (ROTORMAP)











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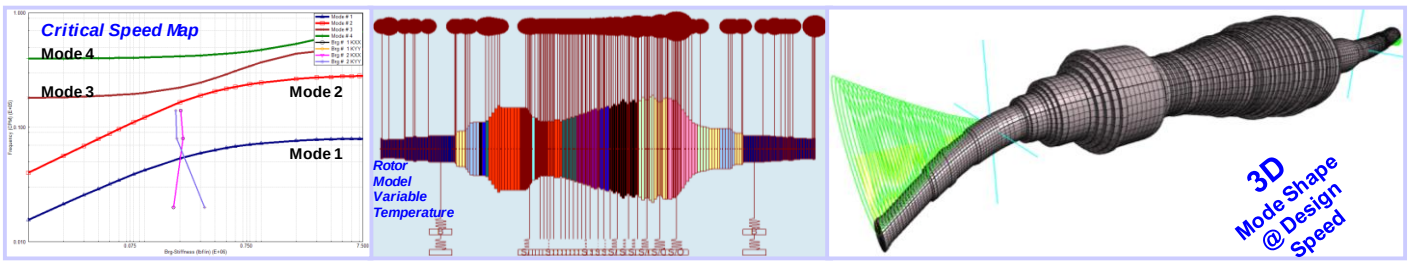
Rev:20230801

The rotor dynamics lateral vibration analysis package uses a finite-element based formulation, for performing damped and undamped **natural frequencies, mode shapes** and **stability** (ROSTAB & ROTORMAP), **synchronous unbalance response** (ROSYNC) , **steady-state response** (ROSSRP), and **non-synchronous time-transient response** (RORESP) of rotating machinery. The five sub-modules are integrated by ROTLAT's user interface. The user interface controls the sub-modules to provide a complete rotor/bearing system dynamic analysis environment integrating the rotating assembly with its support bearings, wear-rings, seals, aerodynamic effects, support structural flexibilities, etc.



ROTLAT incorporates advanced modeling features and capabilities including the following:

- Rotor of various configurations: Solid, Hollow, Tapered & Stepped.
- Shaft material damping.
- Gyroscopic effects (discs with angular degrees of freedom).
- Element geometry, stiffness diameter, or element stiffness.
- Bearings of all types: Cylindrical, Conical, Tilting Pad & Rolling Element.
- Bearing models linked to rotating assembly at any station.
- Bearings vertical elevation for accurate bearings load computation.
- Springs: wear-rings, seals, aero-dynamic effects, squeeze-film dampers, etc.
- Springs models linked to rotating assembly at any station.
- Bearings support systems; casing and foundations.
- Static foundation/pedestal flexibility (mass, stiffness and damping).
- Dynamic (frequency dependent) foundation/pedestal flexibility.
- Discs: couplings, impellers, sleeves, etc.
- Moment release (pin-joint) at shaft stations.
- Multiple unbalance forces at any location and phase orientation along the shaft.
- External excitations and body forces: sinusoidal, step, ramp and pulse type functions.

- *The release of RBTS' **ARMD Version 6 Rotor Dynamics** is a major milestone in the product's development history, rolling out a **completely new and improved** graphical user interface for the package with enhanced numerical capabilities and analysis features. The software's front end was redesigned with our customers' and industry's input to incorporate the most logical, efficient, and productive techniques to model and analyze complex rotor/bearing systems for lateral vibrations.*

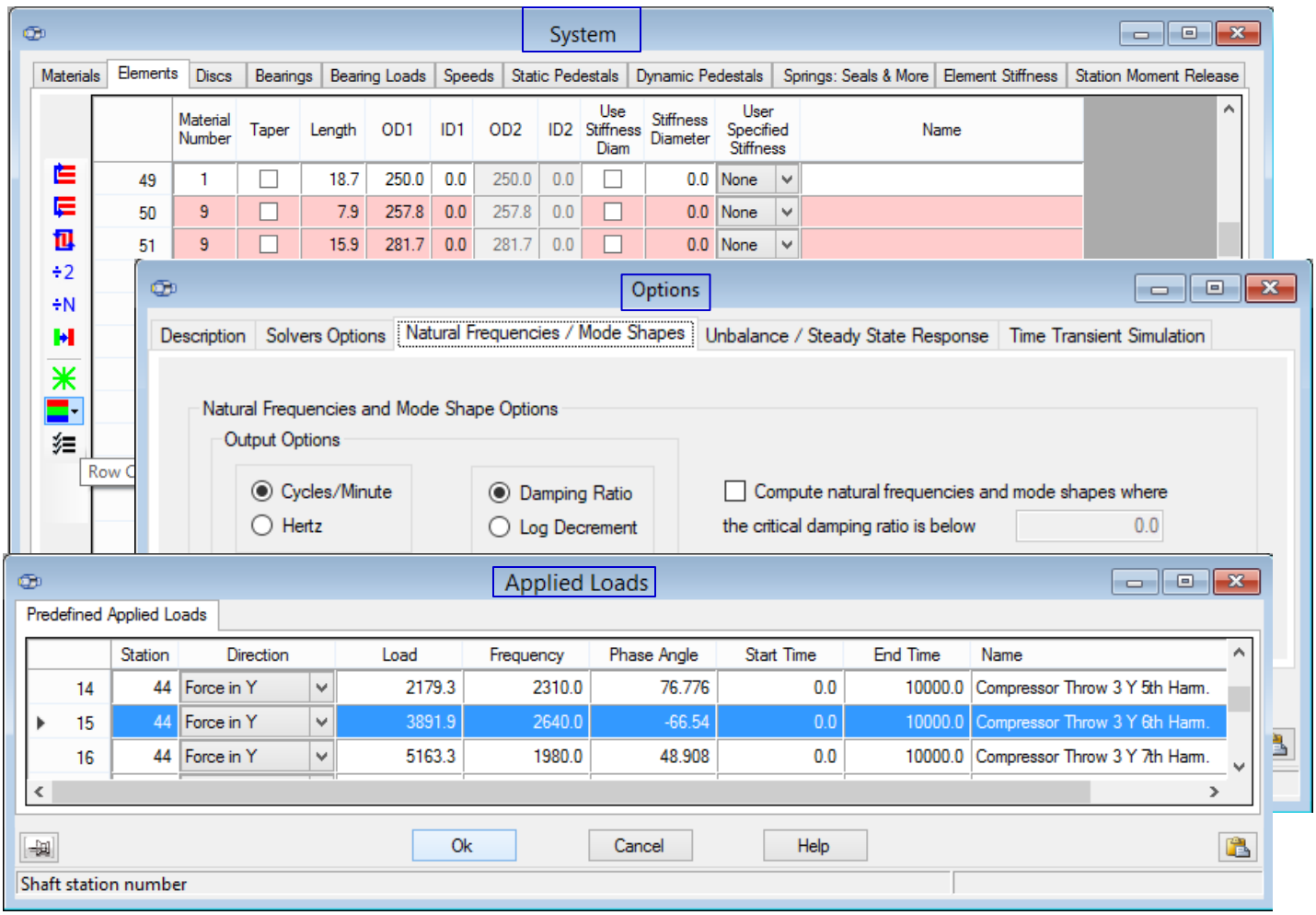
ARMD™ V6.2 – ROTLAT Package

ARMD ROTLAT users will immediately see the improvements as element, shaft, and system data are presented in a flatter format, with key fields and analysis options readily visible and accessible from the main data entry screens. Engineering productivity to design models is vastly improved as shafts and systems can be easily imported from user-generated component template models. Furthermore, the ability to simultaneously run multiple instances of the program permits rapid side-by-side comparison of results.

By identifying new trends from industry standards, along with RBTS' involvement in turbomachinery standards revisions, new technical features were added to the software. Addition of equivalent element stiffness diameters, user specified stiffness for such elements as flexible coupling or disk plate, expanded user-defined forces application, better access to temperature dependent properties, seamless integration of modeled bearings and springs (such as wear-rings, seals, aerodynamic effects, squeeze-film dampers, etc.) all combine to provide more accurate modeling and better matching of analysis results to actual system empirical results.

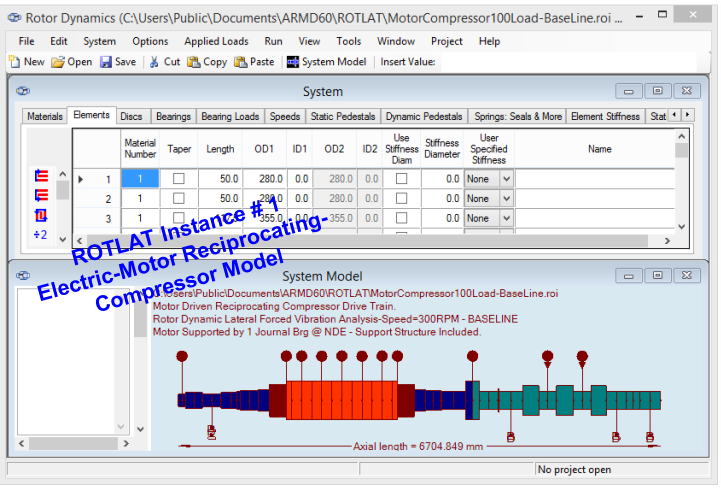
New Enhanced Modeling, Usability and Technical Features:

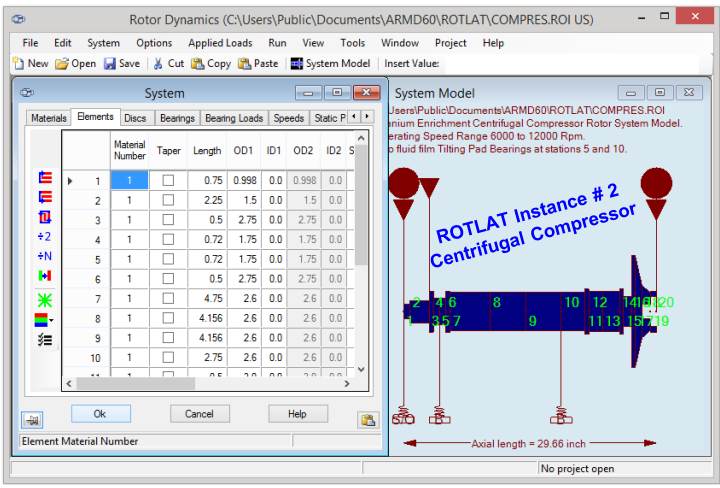
- **Improved TAB layout**. Redesigned for more direct and faster access to data input locations and results. Important functionality is brought forward into the TAB structure, thereby eliminating the need to select from drop down or pop-up menu lists.



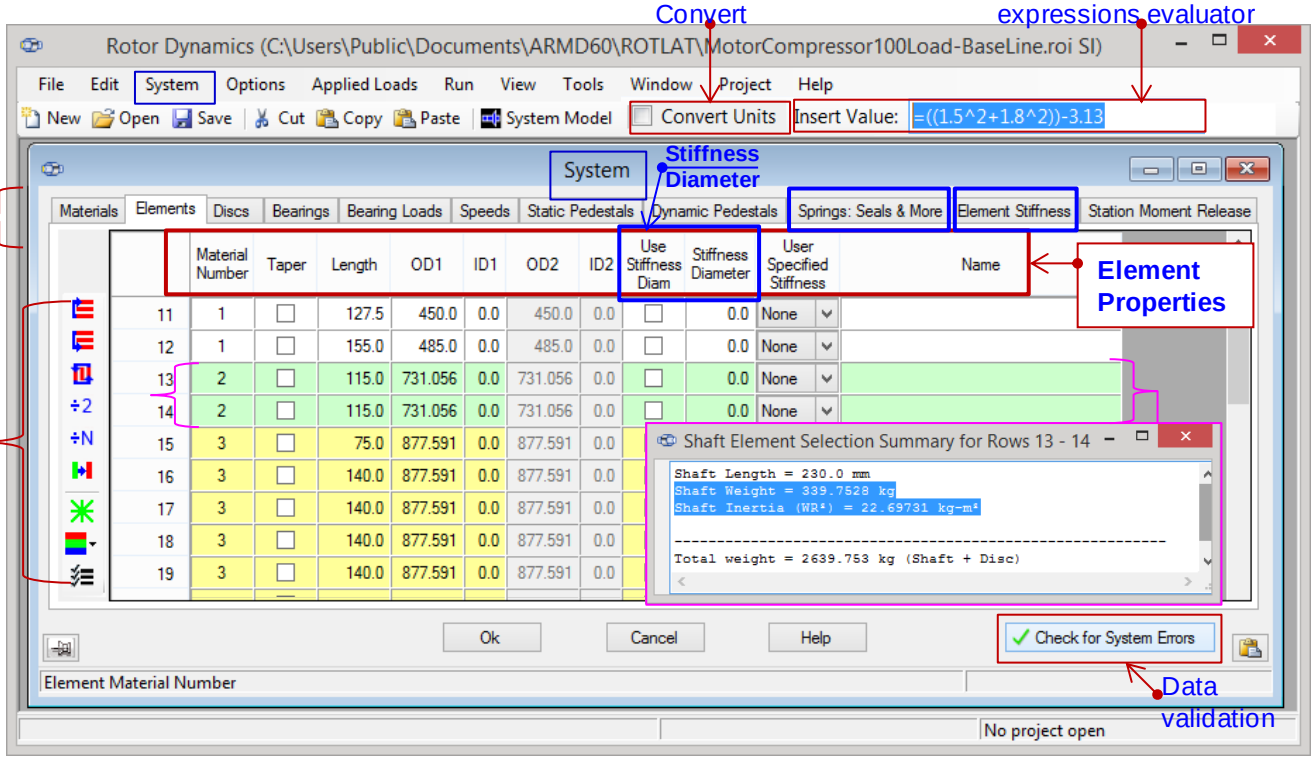
ARMD™ V6.2 – ROTLAT Package

- **Multiple instances of ROTLAT**. The newly developed package can now **open simultaneously multiple instances of ROTLAT**, so modeled shaft and components can be moved easily between different system models to allow fast, side-by-side comparison of model variations and analysis results. This functionality permits multiple instances of ROTLAT Version 6 or Version 5.8 to be accessible on your screens.





Many of the improvements incorporated into the ARMD ROTLAT Version 6 are specifically directed towards simplicity, increasing usability and increasing productivity as illustrated bellow:



Tool Strip

- Move row Up
- Move row Down
- Reverse order of elements on the shaft
- Split Element
- Divide into N elements
- Change material
- Mark/unmark elements
- Color rows
- Get Summary

ARMD™ V6.2 – ROTLAT Package

- **Evaluate Mathematical Expressions**. When entering data to cells, data entry field has the ability to evaluate mathematical expressions, without having to launch a calculator app.

- **Whole Number**. Display for improved legibility, defaulting to scientific notation when required.

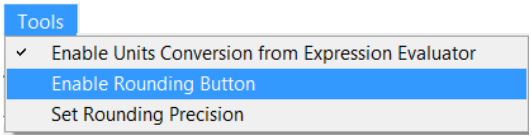
- **Auto Convert Units**. Automatically computes the units conversion when modeling a system with different components using mixed SI and English units. Example: You have a few inch dimensions to enter amongst hundreds of mm values, just check the box for auto conversion.

- **Automatic Cell Validation**. Performed at data entry time. The program now reviews data grids for incomplete, invalid, or nonsensical entries, providing an error flag and correction recommendation. This applies to mass-elastic data fields, user defined torques, and required solver data inputs.

- **Data validation error diagnostics** quickly walks user through any model input errors. A mouse click navigates the user to the next error found.

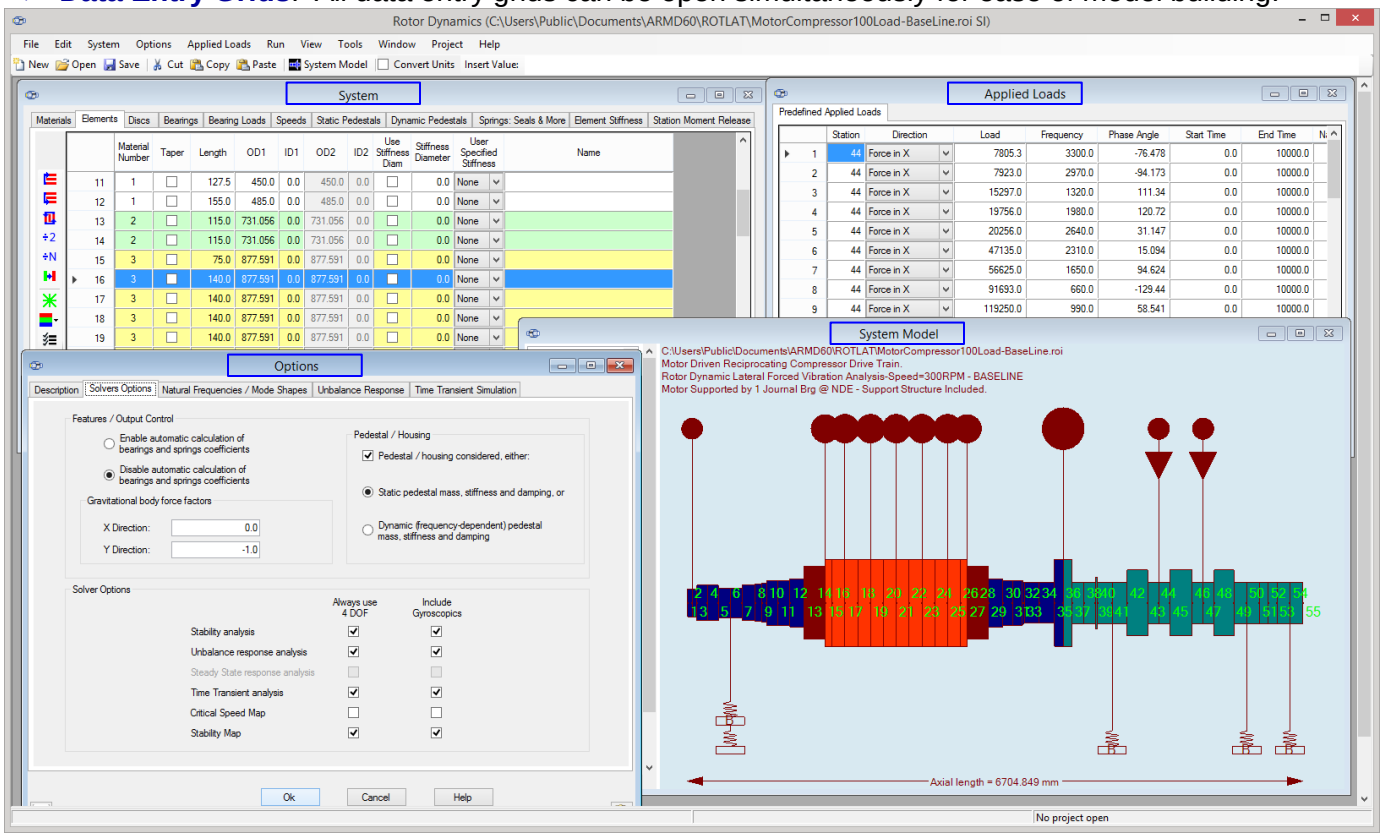
- **Row Tagging**. Row marking/tagging for quick identification and rapid recall, advantageous for multi-shaft systems with very large numbers of elements.

- **Round Function**. Round function for data entry fields is accessible from the Tools menu, and can be declared for all data fields.



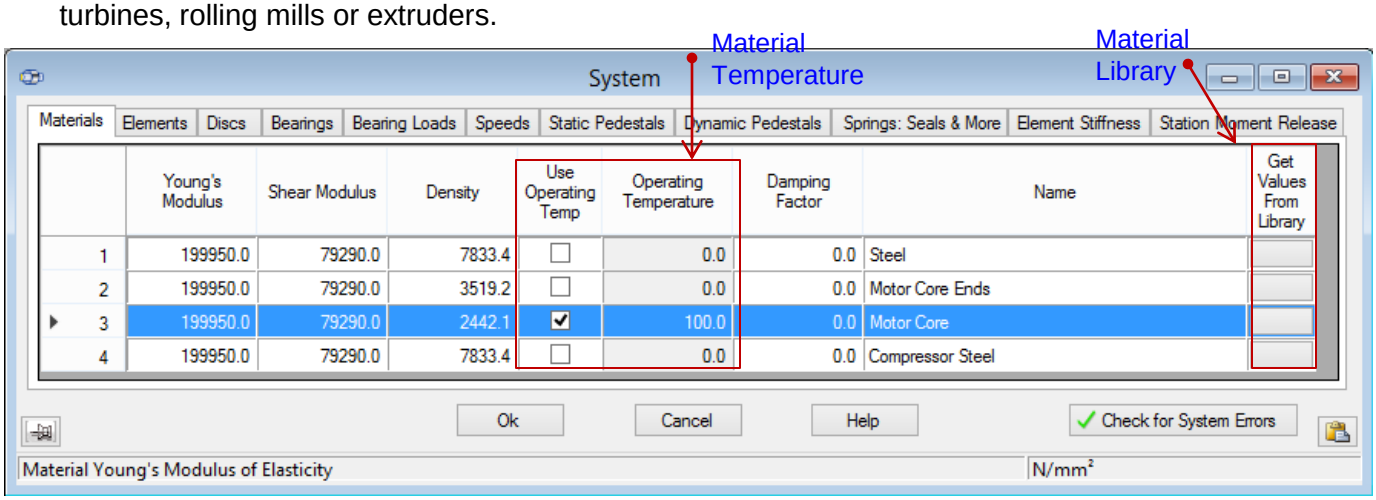
- **Tool Strip/Bar and Buttons**. Replaces hidden right-click menus to provide enhanced visibility of functions and features.

- **Data Entry Grids**. All data entry grids can be open simultaneously for ease of model building.



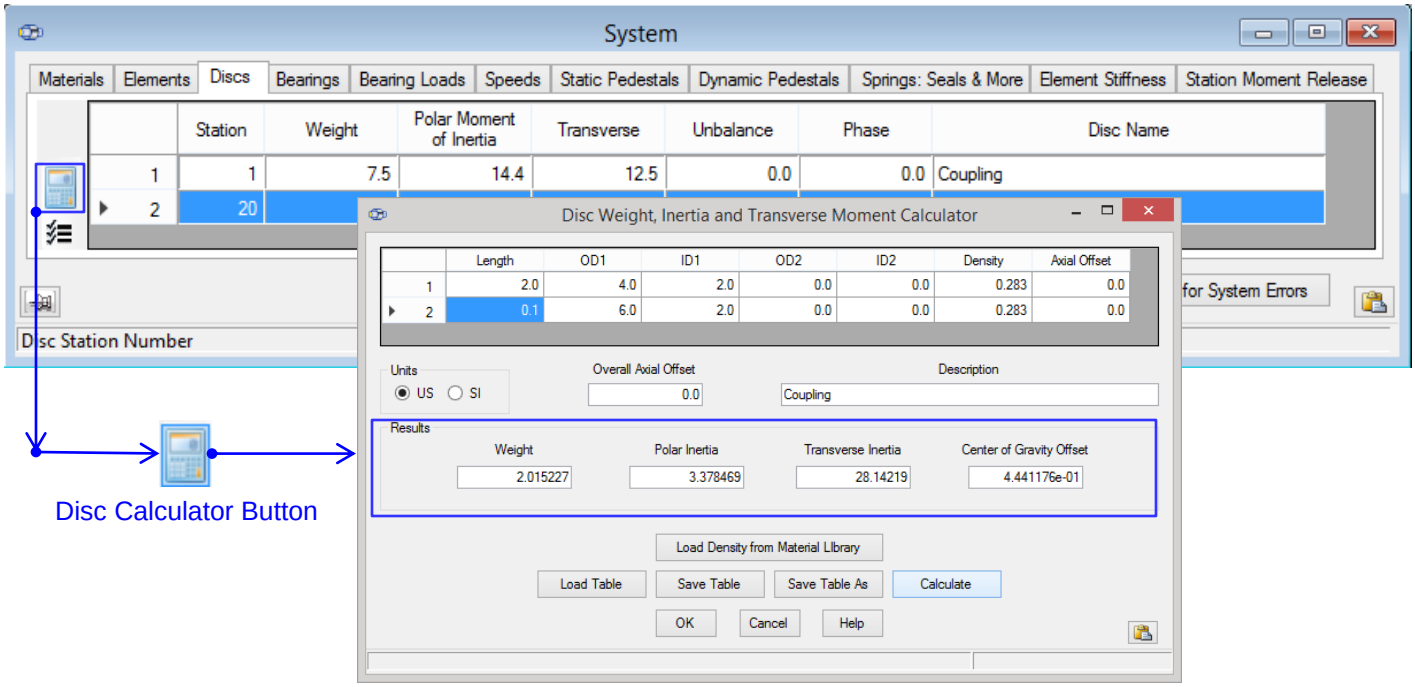
- **Data Entry Menus**. All data entry menus are visible at the Grid Input page. Grids now feature selection check boxes and editing buttons where appropriate.

- **Shaft Material Temperature**. Material operating temperature is readily input and enabled, to capture the temperature dependent material properties and their effect upon rotating assembly dynamic characteristics. Particularly useful for shafts in high temperature applications like steam turbines, rolling mills or extruders.

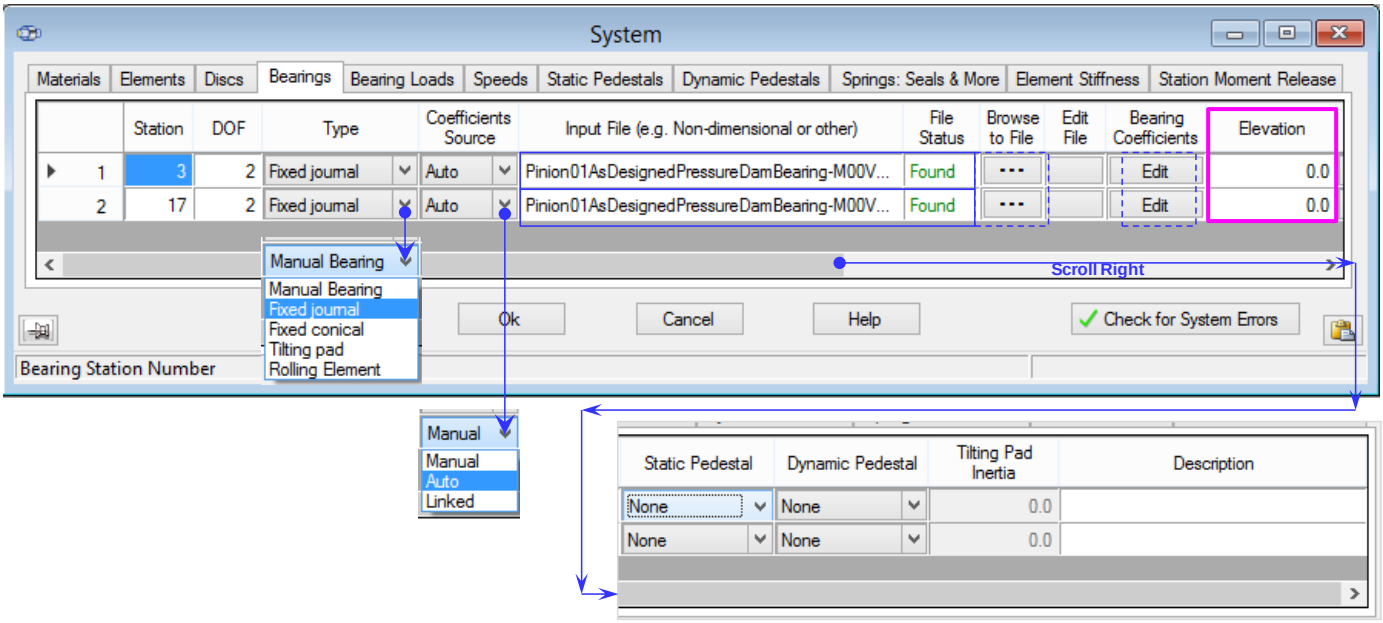


- **Stiffness Diameter** can be used to enter the equivalent mass-elastic properties of complex shaft sections, motor lamination stacks, shrunk on disks, etc. When selected, stiffness diameter is used to compute element stiffness while element geometry is used for computing element weight and inertia properties.

- **Discs & Disc Calculator**. Discs representing concentrated mass with/without inertia properties can be located at any station along the shafting system. A disc calculator is implemented in ROTLAT to compute weight, polar and transverse moments of inertia for user defined single or multiple disc geometries. Calculated weight and inertia properties are automatically placed in the appropriate cells in the Discs form.

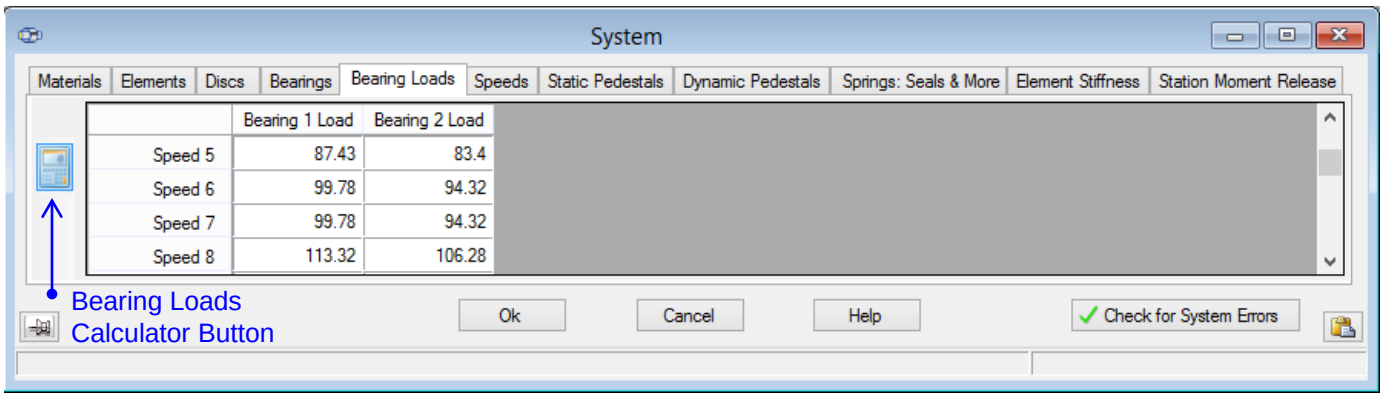


- **Bearings** can be located at any station along the shafting system. Bearings are the fundamental elements supporting the rotating assembly, and any internally generated or externally applied forces and moments. Their dynamic properties (stiffness and damping coefficients) can be manually specified or automatically generated when bearing models are linked to specified stations on the rotating assembly.



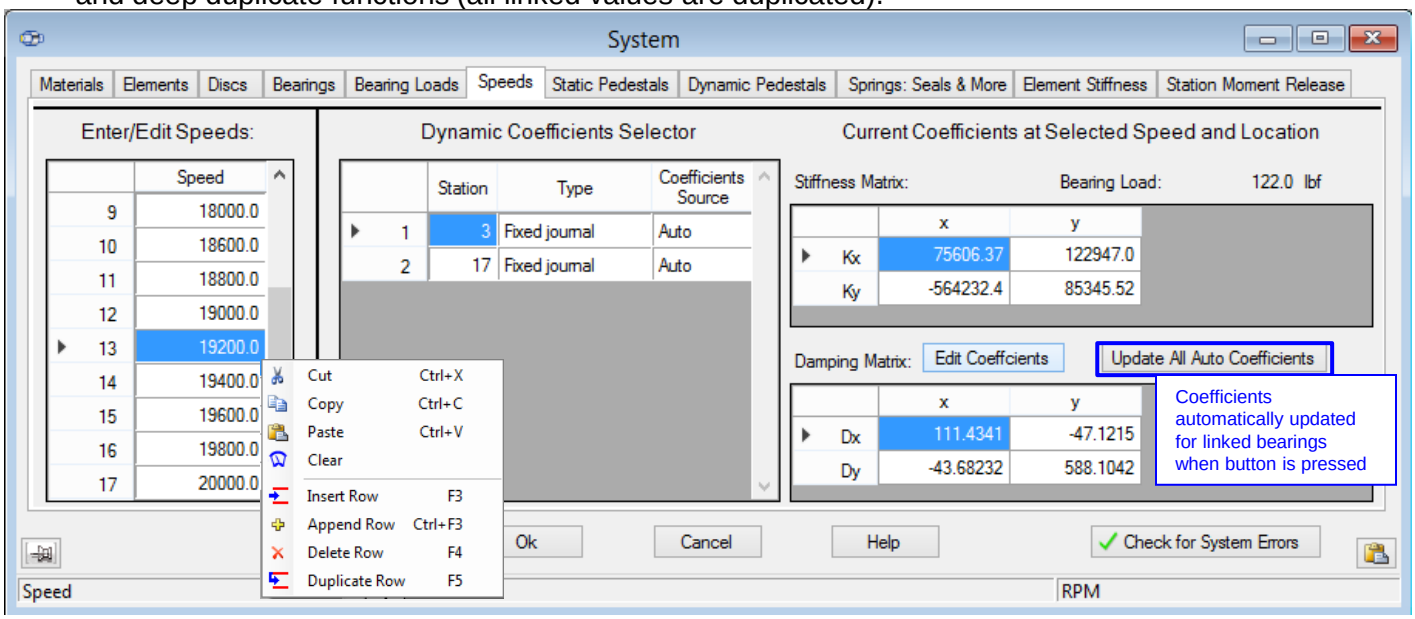
Typically, a bearing has two degrees-of-freedom (X and Y directions, Z being the rotational axis) which is the default setting. ROTLAT can accommodate any number of degrees-of-freedom such as **4x4** for bearings with moment stiffness (Rolling-Element bearings or Thrust bearings). Similarly, for Tilting-Pad bearings where pad pitch degree-of-freedom are to be considered (full stiffness and damping coefficients **NxN**) the size is set to 2 + number-of-pads).

- **Bearings Loads**. Bearing applied loads due to rotating assembly dead weight and/or externally applied forces and moments on the rotating assembly, can be automatically calculated or manually specified in the form. To automatically calculate bearing applied loads simply press the calculator button on the left side of the form.

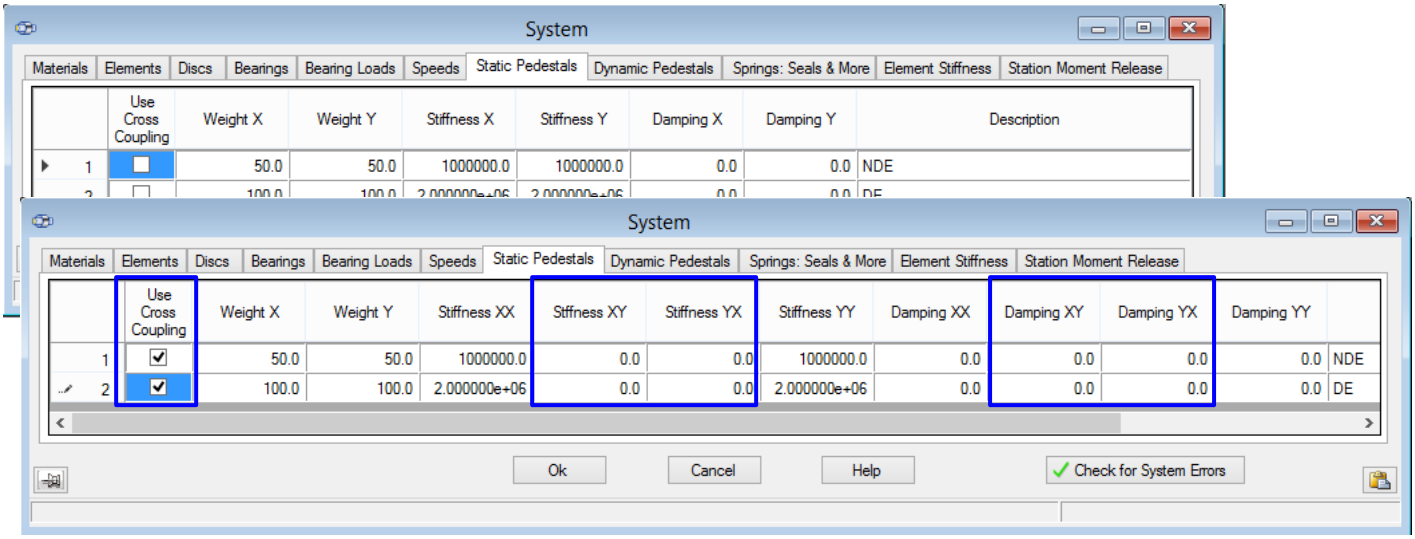


Bearing load calculations may-or-may-not consider dead weight load and externally applied forces/moments, but also will take **bearing elevation** into account to properly compute bearings load magnitudes and directions for each of the bearings supporting the rotating assembly. Bearings **Elevations** are influential when indeterminate supports are considered with three or more bearings such as those installed in multi-rotor power generating units.

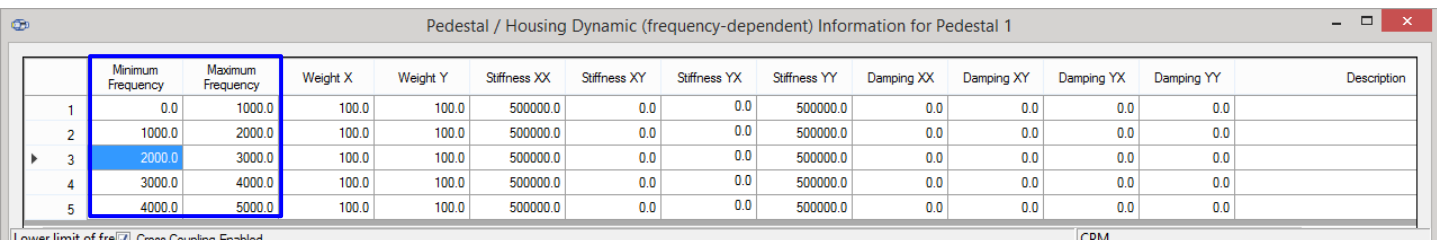
- **Speed Cases**. Many speed cases can be considered in rotor dynamic evaluation with ROTLAT. Speed cases entry and bearing dynamic coefficients viewing are designed for efficiency with copy and deep duplicate functions (all linked values are duplicated).



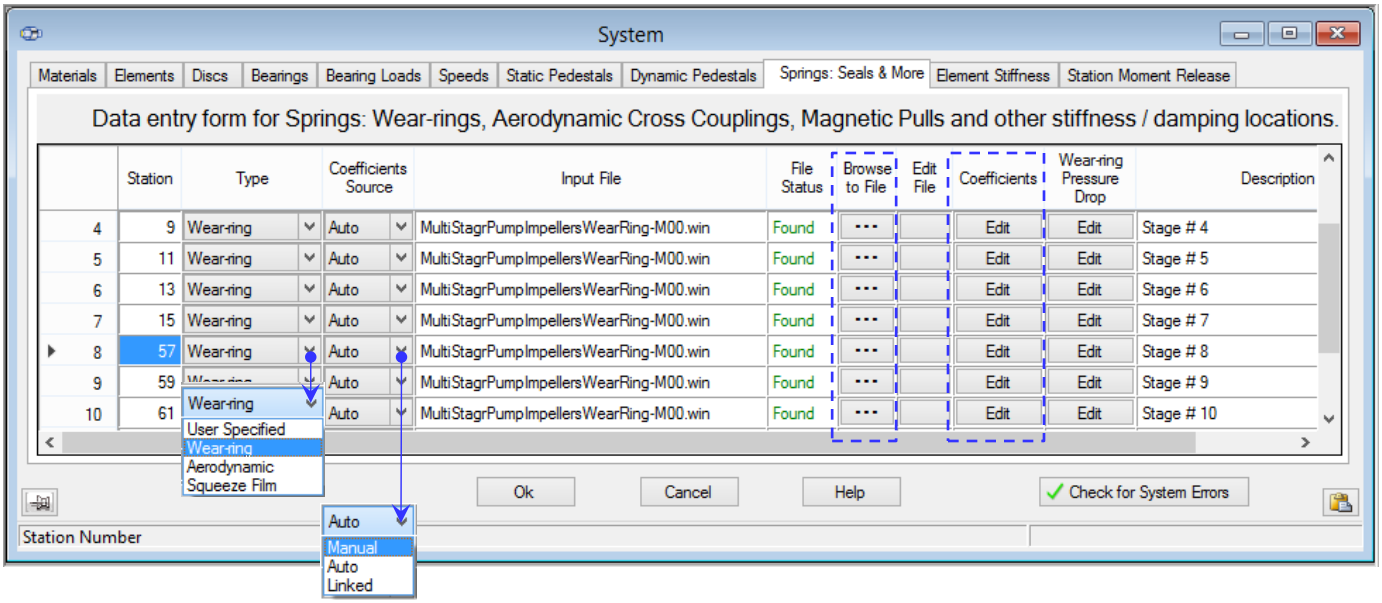
- **Static Pedestal**. Bearings support flexibility such as bearing housing, support structure, etc. can be considered in ROTLAT. These dynamic coefficients are normally defined in the horizontal X-direction and vertical Y-direction with their mass, stiffness and damping characteristics. Any defined static pedestal properties can be linked to any bearing in the system. ROTLAT not only accommodates these coefficients but also can accommodate cross-coupled coefficients as shown.



- **Dynamic Pedestal**. Similar to the static pedestal mentioned above, the dynamic pedestal defines the dynamic coefficients as a function of frequency bands calculated or measured in the field.



➢ **Springs**. Provides the means to introduce dynamic characteristics (stiffness and/or damping coefficients similar to bearings) affecting the rotating assembly. This option permits the user to specify **dynamic effects** such as those arising from **Seals**, **Wear-rings**, Impeller **Aero-Dynamics**, Impeller Hydraulics, Steam Whirl effects, etc. that may be stabilizing or destabilizing forces on the rotating assembly. Their dynamic properties (stiffness and damping coefficients) can be manually specified or for some elements (shown below) automatically generated when these elements are linked to specified stations on the rotating assembly.

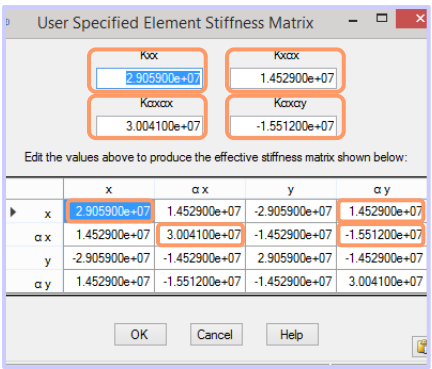


➢ **Element Stiffness**. The element stiffness feature (matrix tab shown below) permits user specification of elements stiffness matrices to be utilized in the shaft element form instead of being computed internally by the solvers from the specified element geometry. This feature allows the specification of element stiffness matrix for such elements as coupling, coupling connections, plate elements, discs, or any other flexible connection along the shafting system.

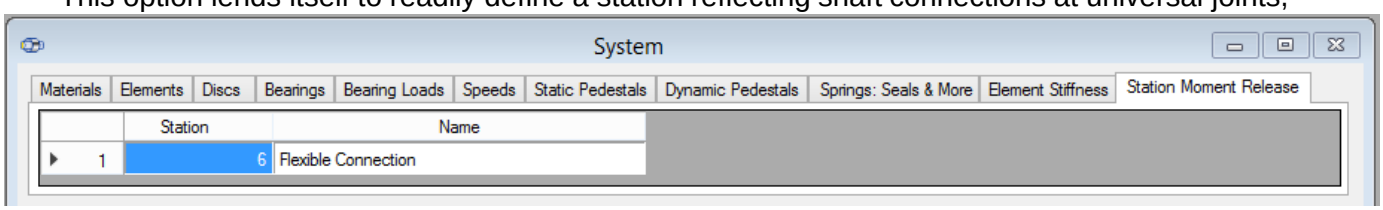
	X	αX	Y	αY
X	1,1	1,2	1,3	1,4
αX	2,1	2,2	2,3	2,4
Y	3,1	3,2	3,3	3,4
αY	4,1	4,2	4,3	4,4

Axisymmetric Non-tapered Element

	X	αX	Y	αY
X	$\frac{12EI}{L^3}$	$\frac{6EI}{L^2}$	$-\frac{12EI}{L^3}$	$\frac{6EI}{L^2}$
αX	$\frac{6EI}{L^2}$	$\frac{4EI}{L}$	$-\frac{6EI}{L^2}$	$\frac{2EI}{L}$
Y	$-\frac{12EI}{L^3}$	$-\frac{6EI}{L^2}$	$\frac{12EI}{L^3}$	$-\frac{6EI}{L^2}$
αY	$\frac{6EI}{L^2}$	$\frac{2EI}{L}$	$-\frac{6EI}{L^2}$	$\frac{4EI}{L}$

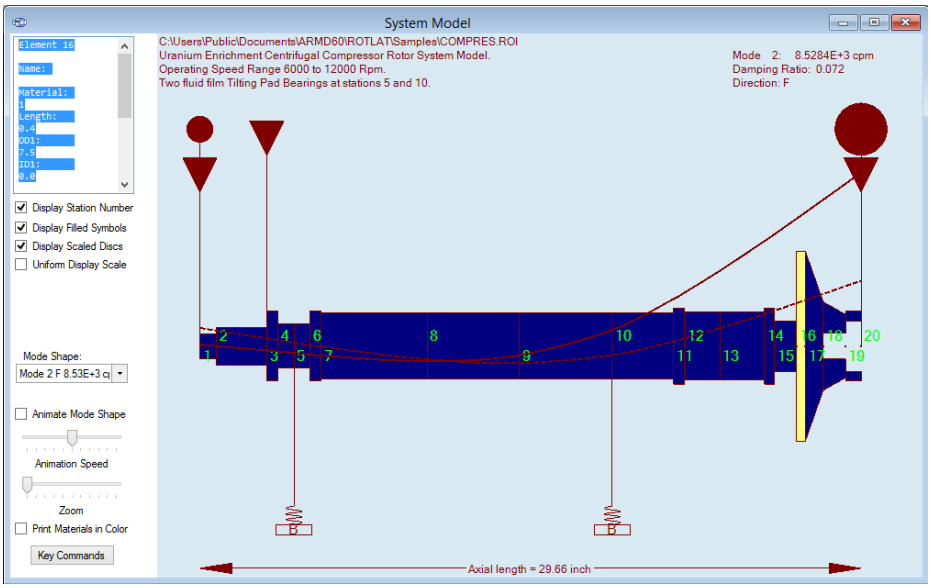


➢ **Station Moment Release**. The station moment release permits specification of stations along the shafting system not to transmit moment forces across the station while transmitting full shear forces. This option lends itself to readily define a station reflecting shaft connections at universal joints,

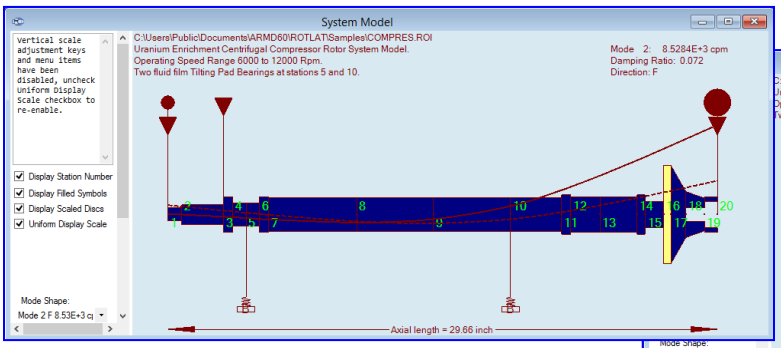


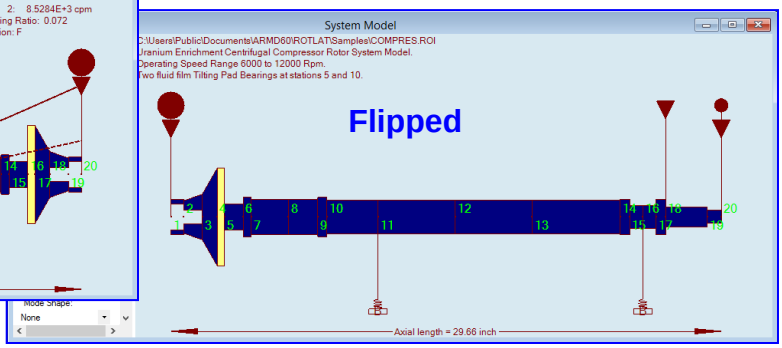
➢ 2-D GRAPHICS MODEL.

Real-time graphics update of the 2-D image corresponding to numeric data input in data grids provides visual confirmation of model correctness while building system models.



2-D Model auto resizing gives user the option to "fit-to-page" complete model. User can automatically view the model with the correct aspect ratio (Uniform Display Scale, shown below), thereby permitting rapid, visual model review. Shaft models can be **flipped from left to right** with a single button click.





Interrogate an element in the 2-D Model Viewer to see all defining element data in a side-bar data window.

Element selection with control keys within the 2-D model viewer permits easy identification of particular cells within large models. This is useful for models with closely spaced thin elements.

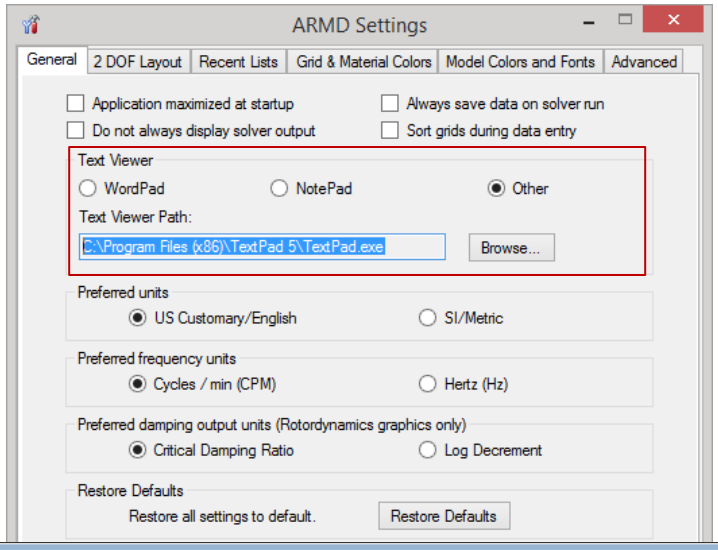
Rotated view option for copying the 2-D model graphic to the clipboard.

Metafile enabled copy and paste of system models and graphics for better report graphics.

Tool panel has been added on the 2-D display window for enhanced graphics control and better visibility of display options.

ARMD™ V6.2 – ROTLAT Package

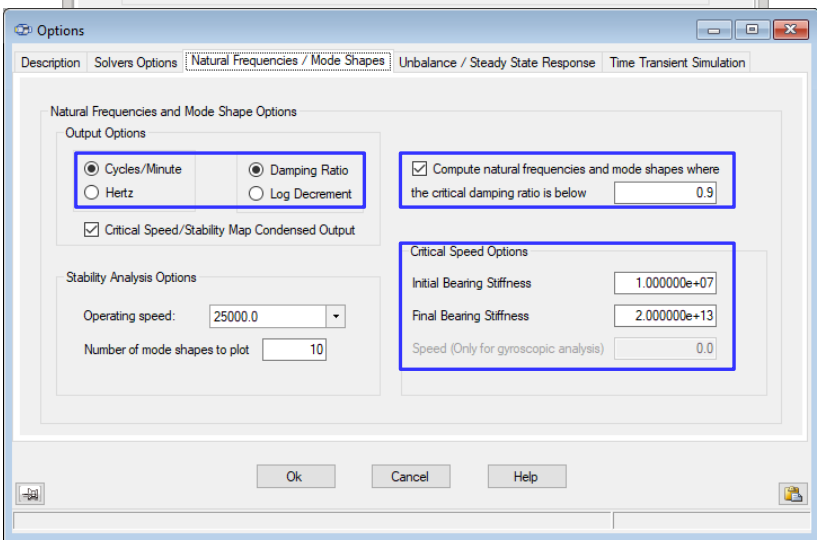
- **Text Output Viewer**. User selectable text output viewer that can be Word, Open Office Writer, Notepad, WordPad, or any other program which accepts text file input. Settings are specified in the ARMD Settings form from the help menu.



- **One-click Quick Chart**. This feature rapidly displays an X-Y graph of entered tabular data for visual verification of correctness. ARMD Graph software is still available for complete graphic analysis capabilities

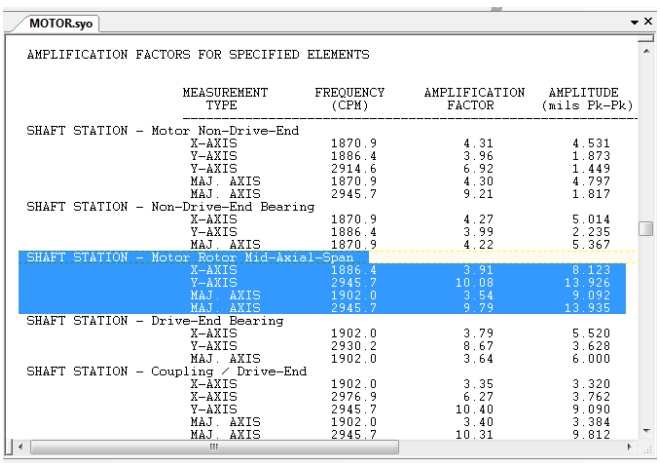
- **Selectable Output Units**. Selectable Frequency Units between CPM or Hz, in accordance with the user's preference, or the industry standard format, can be set simply by checking a box in the options form. Also damping parameter (Damping Ratio or Log. Dec.) can be selected.

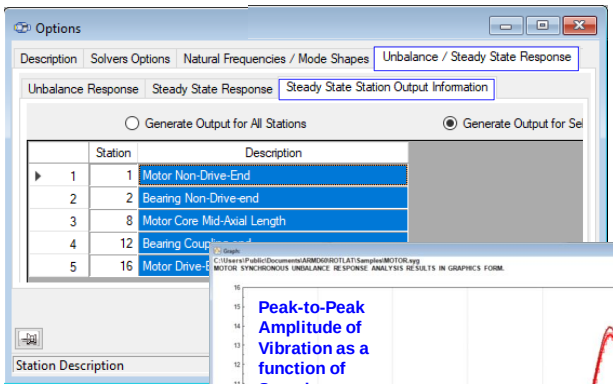
- **Damped Modes**. Users may eliminate graphical presentation of highly damped modes by simply checking a box and specifying damping ratio threshold.

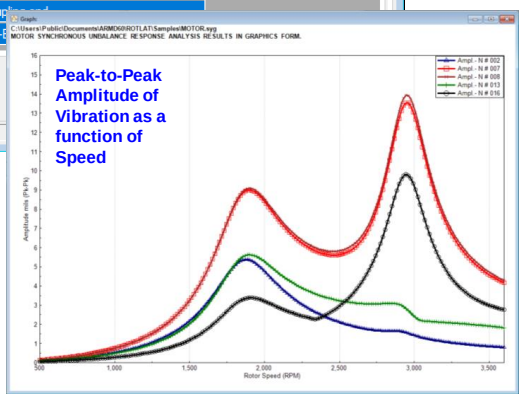


- **Critical Speed Map Options**. Minimum and maximum support/bearing stiffness for critical speed map can be user specified and can include gyroscopic/speed effects.

- **Amplification Factors**. Amplification factors in accordance with API standards are computed for user specified stations by simply specifying the desired stations for this option.



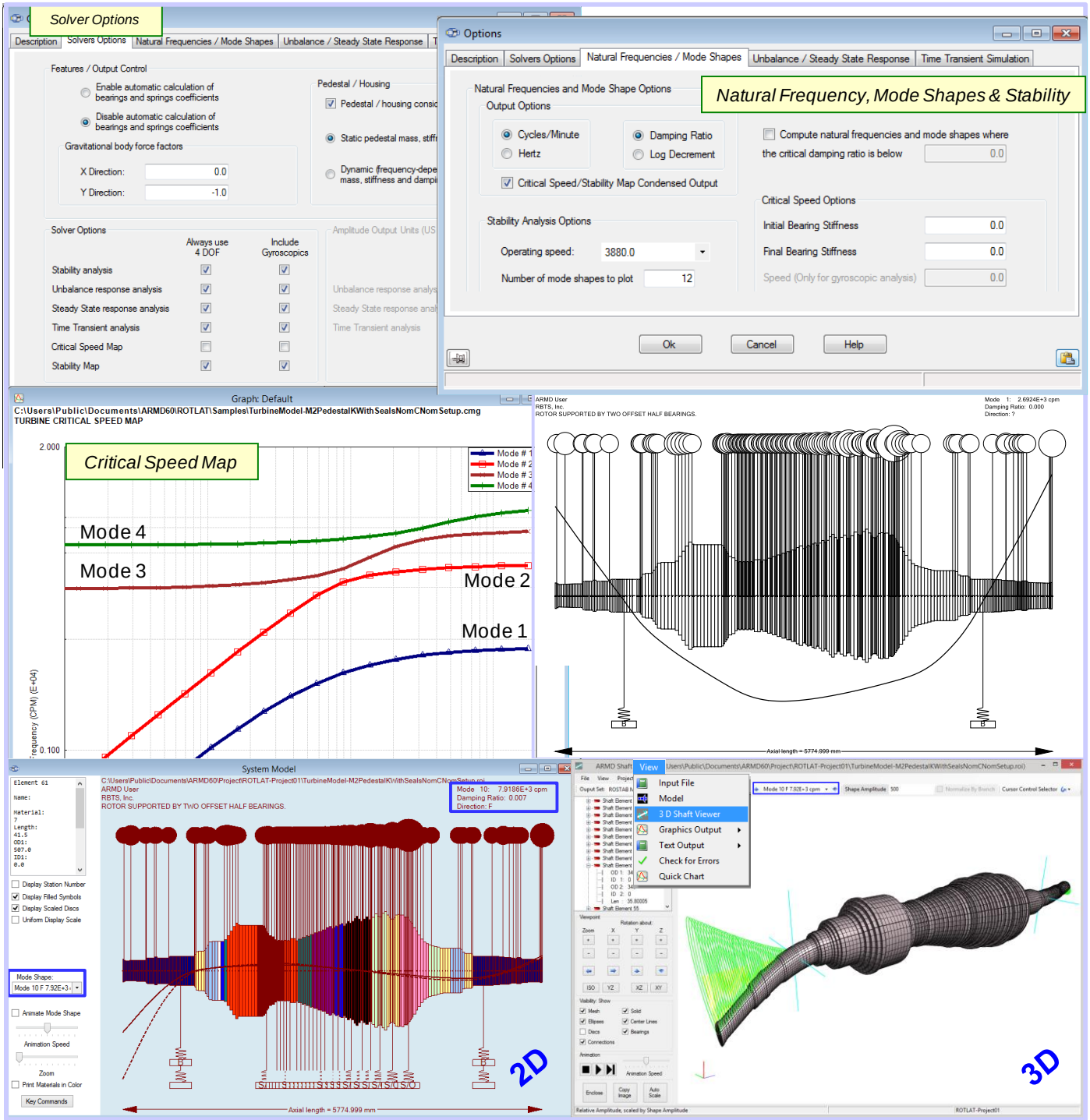




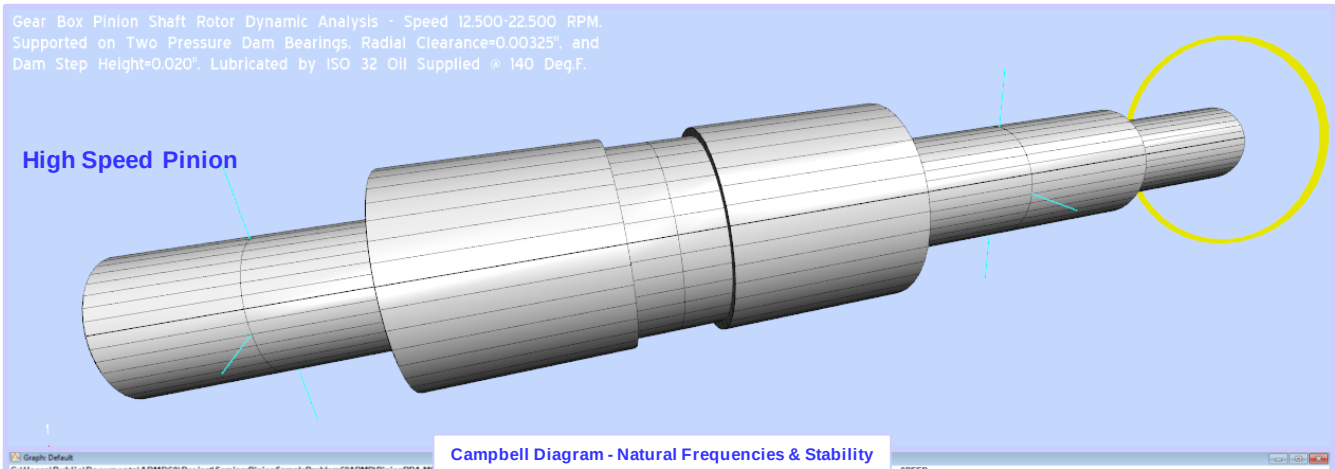
ARMD™ V6.2 – ROTLAT Package

NATURAL FREQUENCY, MODE SHAPE & STABILITY

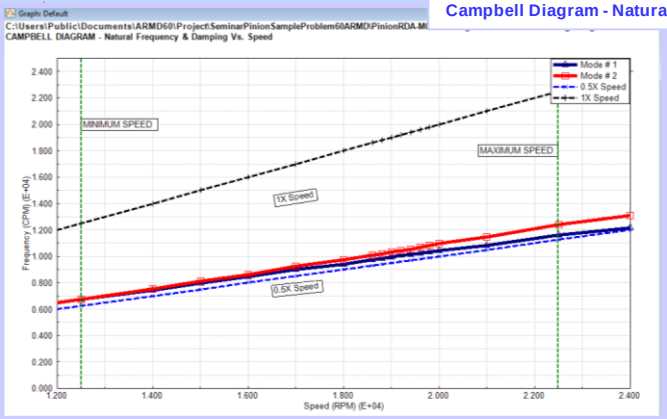
- Natural frequencies & mode shapes
- Damped and undamped simulation
- Stability parameters (damping ratio, logarithmic decrement)
- Rotor orbit direction (forward/reverse precession)
- Critical speed map
- Stability map / Campbell diagrams
- Bearing reaction forces
- Shaft weight, deflection, centerline slope, shaft moment, shear, & fiber stress diagrams

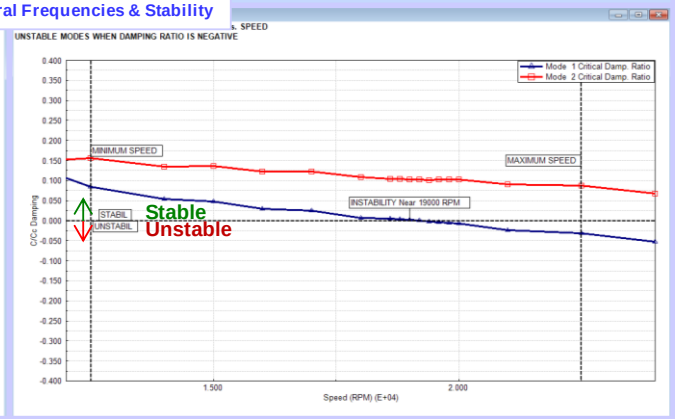


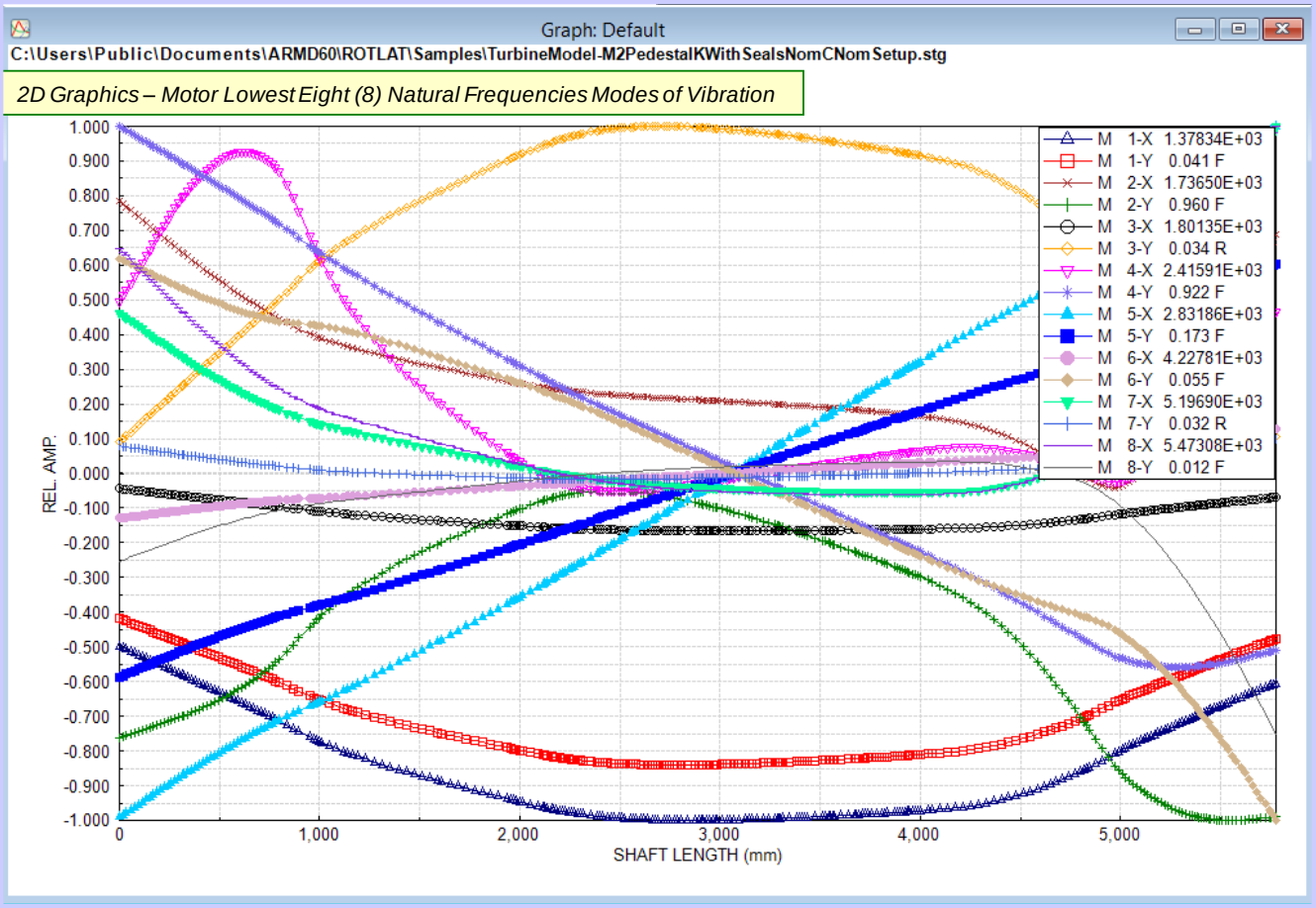
ARMD™ V6.2 – ROTLAT Package



Campbell Diagram - Natural Frequencies & Stability

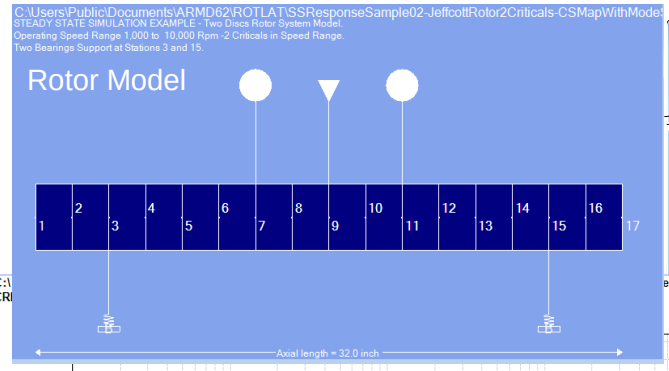


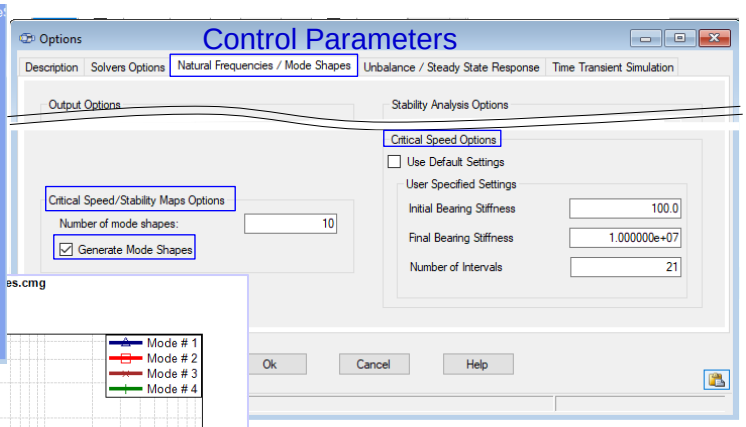


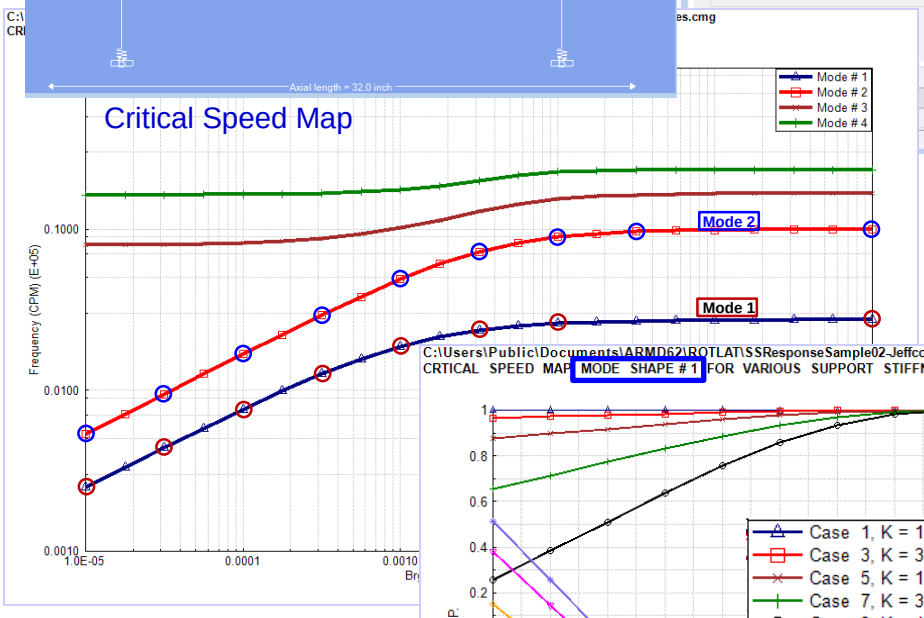


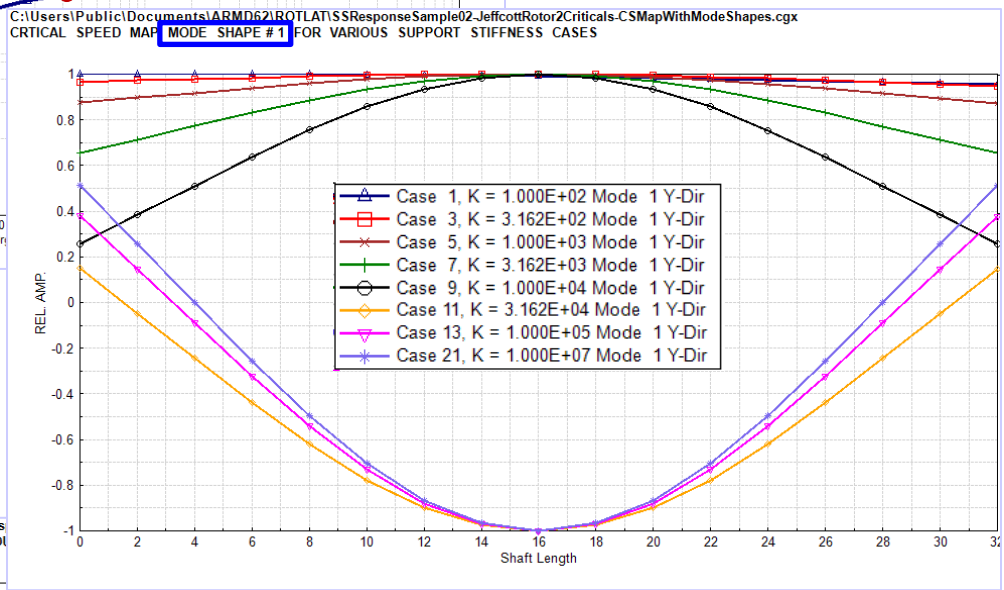
ARMD™ V6.2 – ROTLAT Package

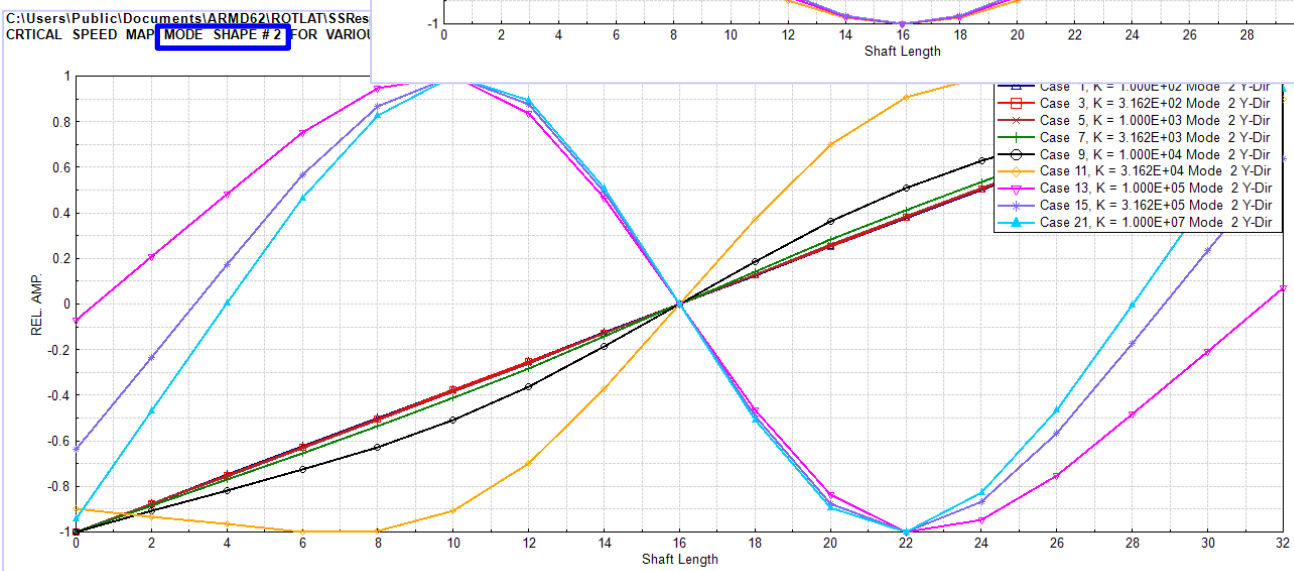
- **Generation of mode shapes as a function of support stiffness for Critical Speed maps and as a function of speed for Stability maps.**







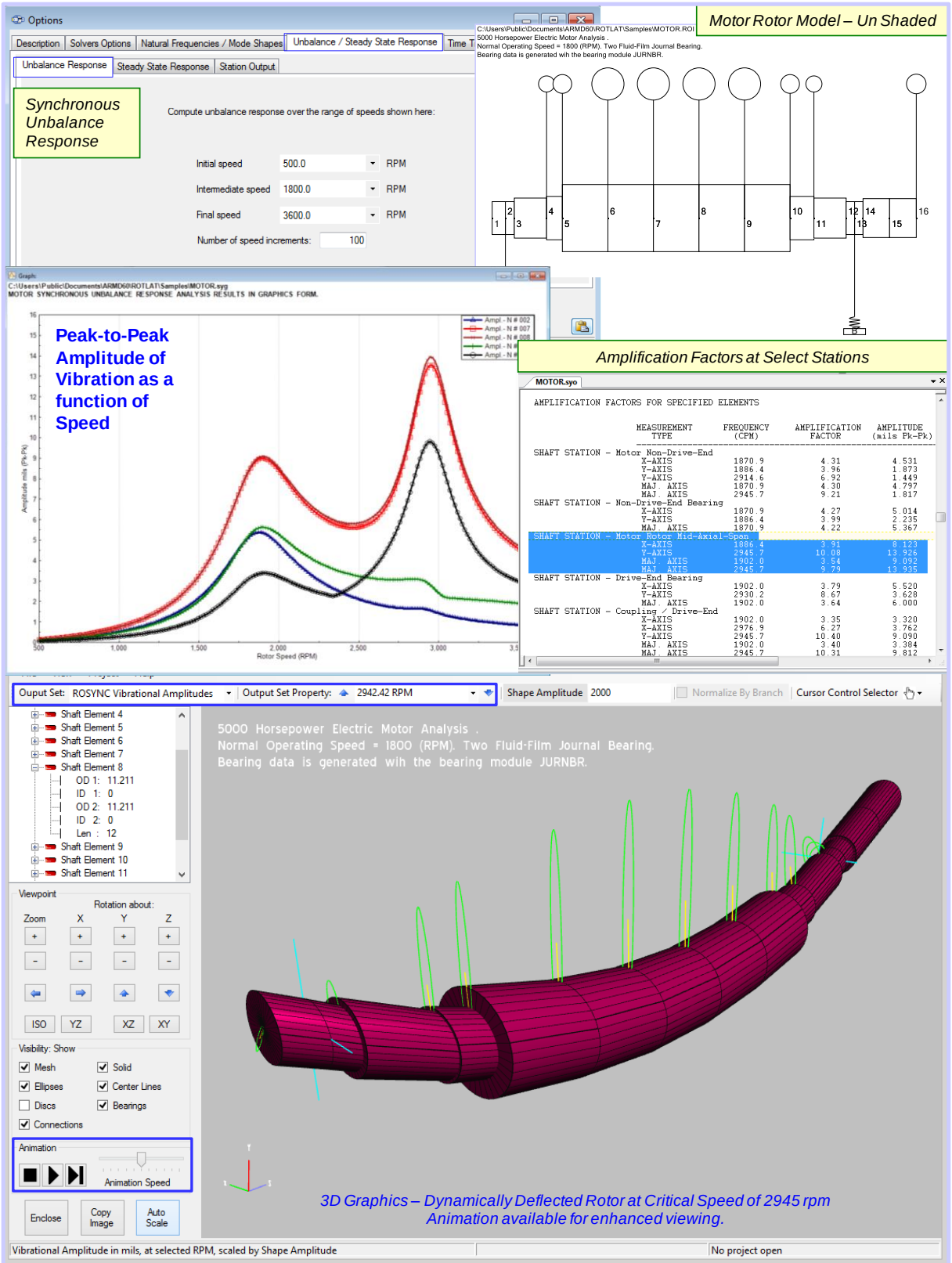




ARMD™ V6.2 – ROTLAT Package

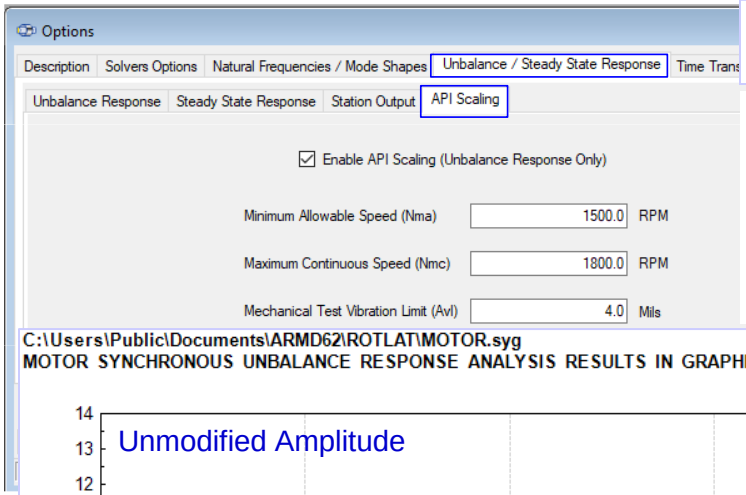
Synchronous UNBALANCE & STEADY-STATE RESPONSE

- Multiple unbalance planes/forces
- Various types of external excitations and body forces including harmonic excitations/orders.
- Vibratory amplitudes and orbits
- Magnitude and phase (Bode plot)
- Rotor shape plots
- Dynamic forces and moments
- Foundation vibratory amplitudes
- Forces/moments transmitted to bearings and foundation
- API Amplification factors



ARMD™ V6.2 – ROTLAT Package

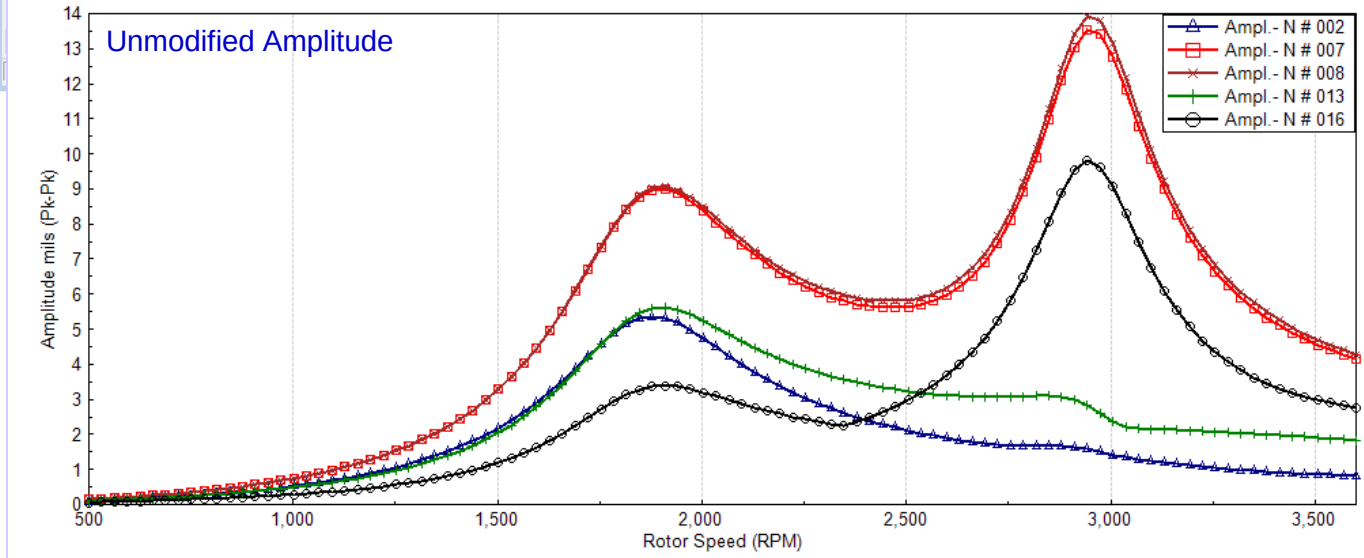
- Implement feature for scaled amplitude of vibration to be user specified in the below form “API Scaling” tab. For example, API 617 criteria for compressors states “vibration response at each vibration probe, for considered unbalance amount and for cases of interest, shall not exceed the mechanical test vibration limit Avl, of 25.4 micrometer (1.0 mil) or the equation shown below, which ever is less".



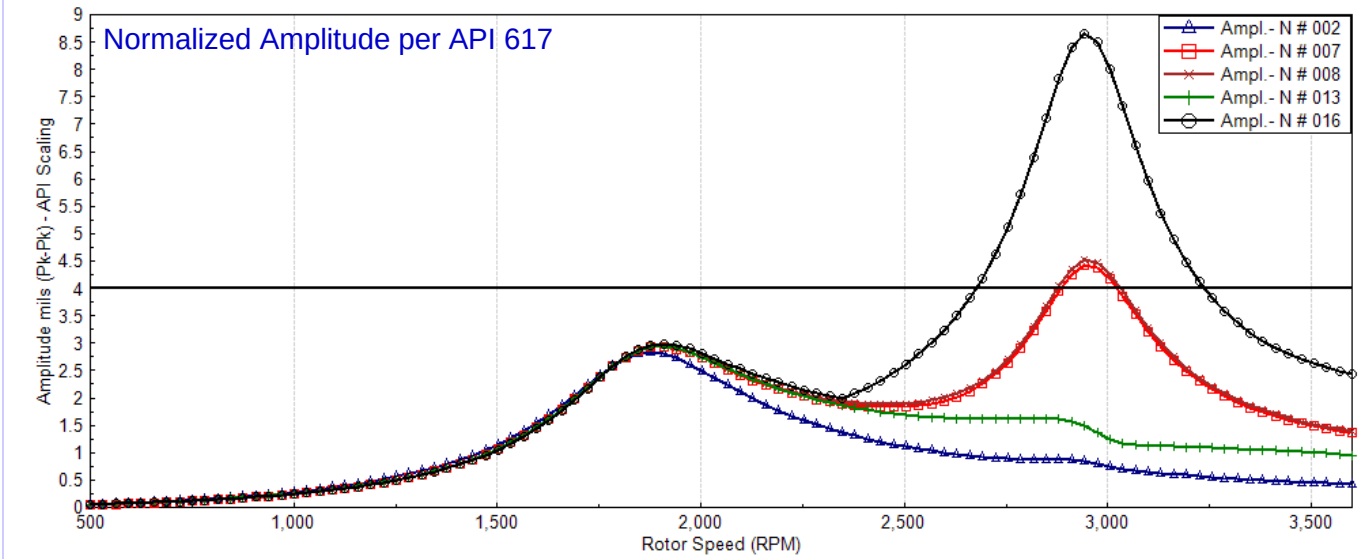
In SI units: Avl = 25.4 Sqrt(12,000 / Nmc)
In USC (English) units: Avl = Sqrt(12,000 / Nmc)

Mechanical test vibration limit value Avl is computed by the user in accordance with appropriate equipment API specifications and specified in the form. Solution is performed and results are normalized utilizing the Avl value, as shown in the below generated graphics output.

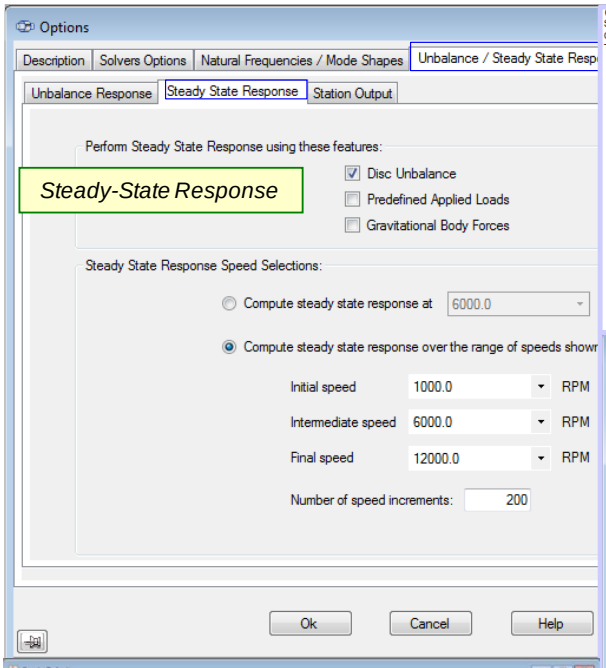
C:\Users\Public\Documents\ARMD62\ROTLAT\MOTOR.syg
MOTOR SYNCHRONOUS UNBALANCE RESPONSE ANALYSIS RESULTS IN GRAPHICS FORM.

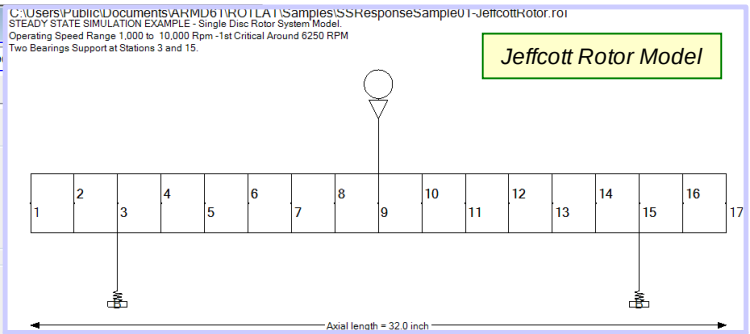


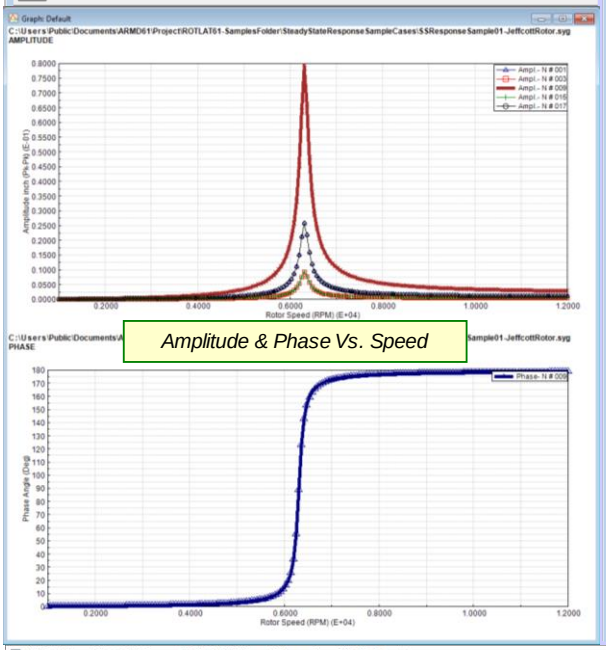
C:\Users\Public\Documents\ARMD62\ROTLAT\MOTOR.syg
MOTOR SYNCHRONOUS UNBALANCE RESPONSE ANALYSIS RESULTS IN GRAPHICS FORM >> Per API 617 Normalized Amplitude <<.

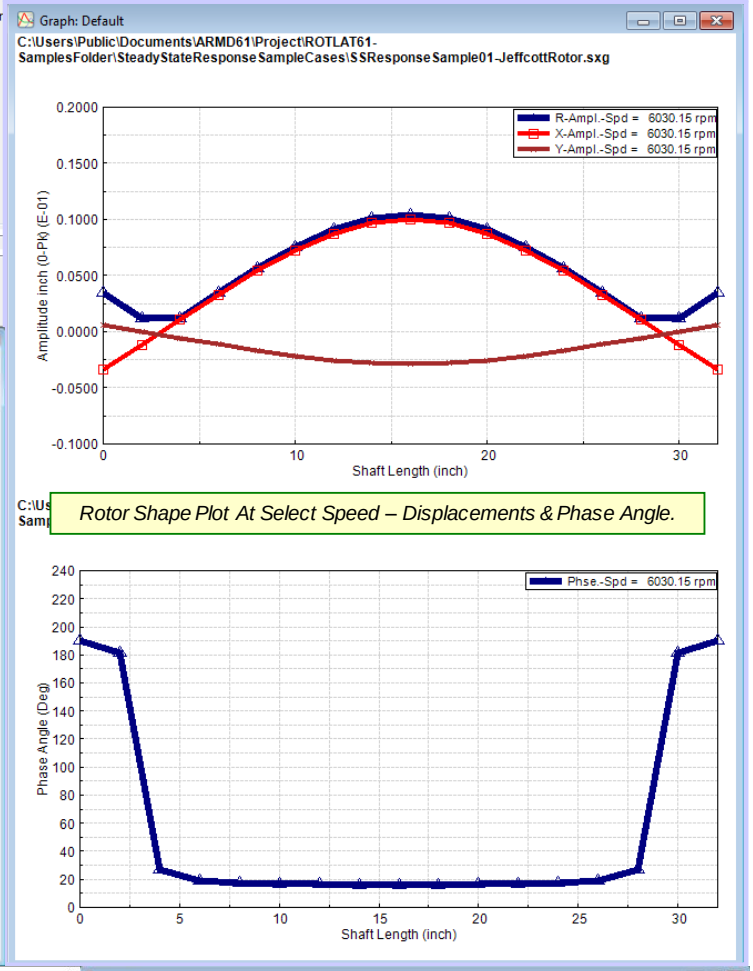


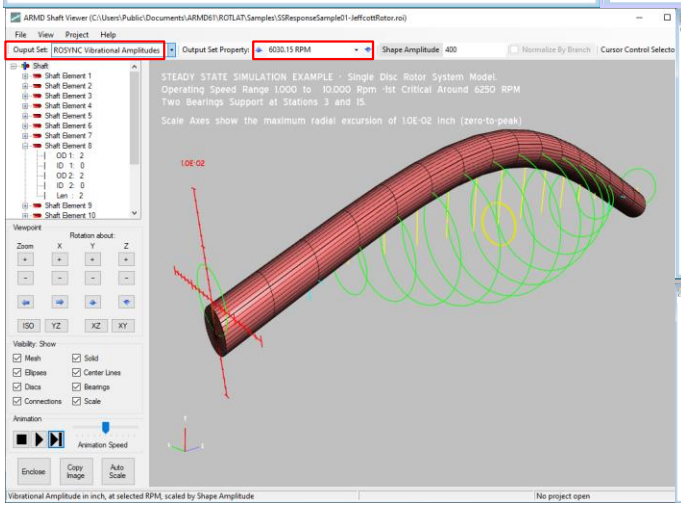
ARMD™ V6.2 – ROTLAT Package

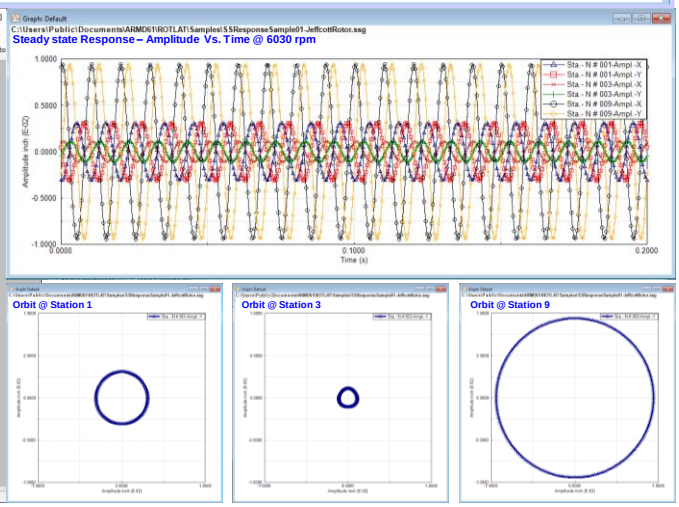








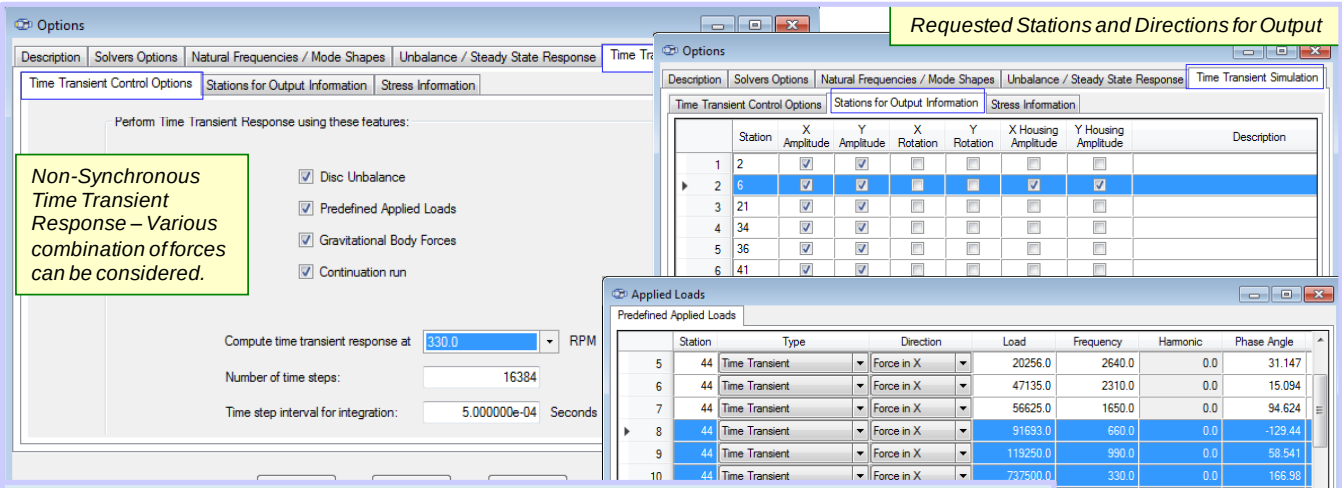


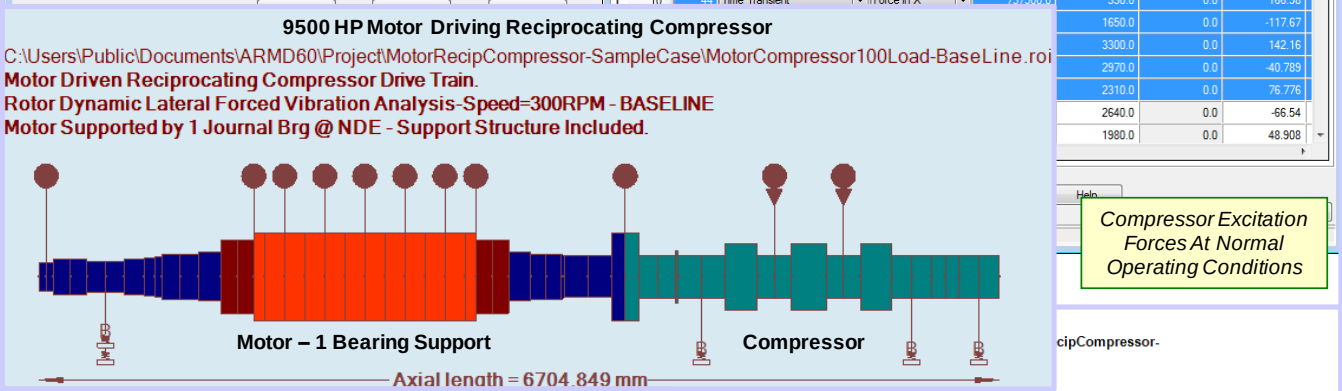


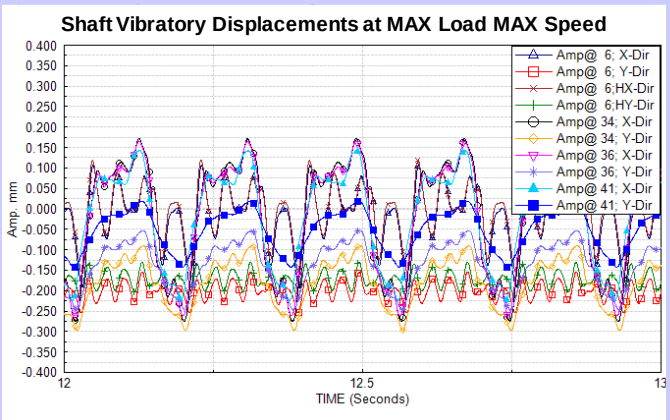
ARMD™ V6.2 – ROTLAT Package

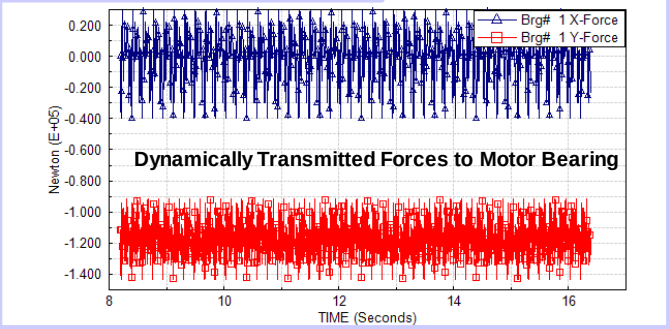
TIME-TRANSIENT RESPONSE (Non-Synchronous)

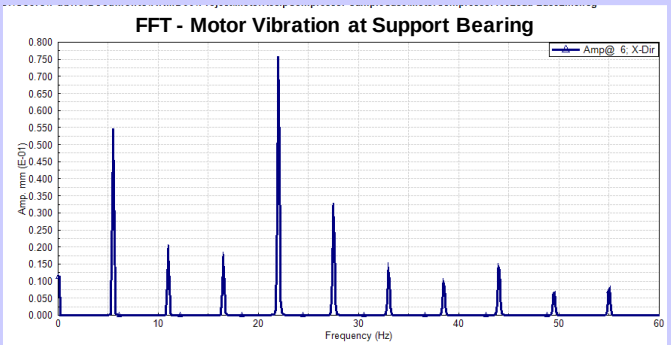
- Gravitational and external forces: Multiple sinusoidal, step, ramp, pulse and unbalance
- Vibratory amplitudes time history
- Rotor orbits
- Dynamic forces and moments
- Dynamic stresses
- Transmitted forces and moments
- Pedestal vibratory amplitudes

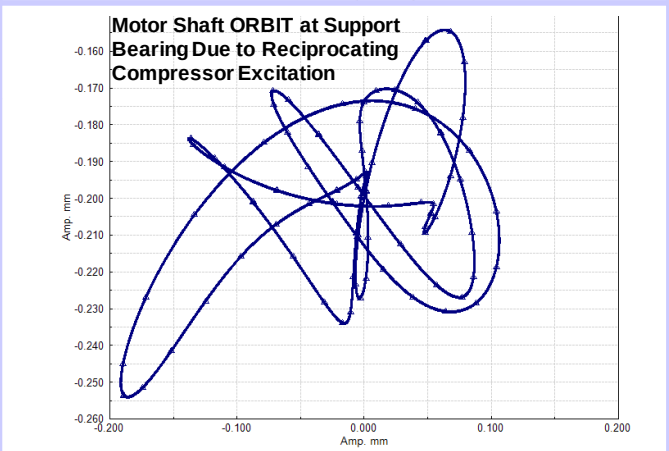












Purchasing Options

ARMD is constructed from various solution modules. It can be tailored to suit your needs and budget. You may purchase any combination of programs/modules or all if you wish. Licensing is available as a single seat or multi-seat network configuration. With your purchase, the package includes the software (CD or download), quick start manual, electronic user's manual, technology transfer and training session (optional), updates, maintenance, and support.

System Requirements:

Personal computer with Microsoft Windows 8, 10, 11 or higher (32 or 64 bit).

Remember, with **RBTS**, you get more than just the programs, you get the company with more than 50 years of experience in the areas of tribology and machinery dynamics.

For further information, please contact us.

RBTS, Inc.

Rotor Bearing Technology & Software
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Phoenixville, PA 19460
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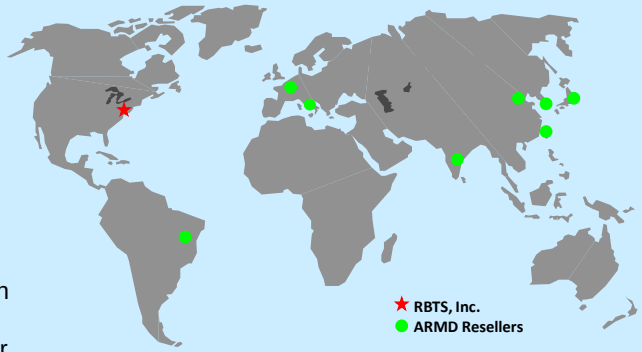
Email: **info@rbts.com**

ARMD™ - The Worldwide Leading Software For Rotating Machinery Analysis

***A**dvanced **R**otating **M**achinery **D**ynamics*

ARMD is a well established software package used worldwide to perform complete rotating machinery dynamic analysis. ARMD employs a user-friendly interface and window environment with pull-down menus and context-sensitive help. ARMD integrates the most advanced and complete rotor dynamics, torsional vibration, and bearing analysis programs under one environment in a seamless fashion to give you the power to model your rotating machinery with ease, efficiency, and above all accuracy. Some applications in which ARMD has been utilized include rotating machinery such as a miniature air turbine for a dental drill, a large turbine generator set for a power plant, a small compressor for an air conditioner, a pump for an artificial heart, a fuel pump for a jet engine, an electric motor and spindle for a miniature computer hard disk, a canned pump for petrochemical processing plant, synchronous motor driven drive-trains, and a gear box for an Uranium enrichment plant.



RBTS' software has gained international reputation for its:

- **Technical Capabilities**
- **Completeness**
- **User Friendliness**
- **Support & Service**

RBTS, *Inc.*

Rotor Bearing Technology & Software
1041 West Bridge Street
Phoenixville, PA 19460, USA

Please contact ***Dr. Andreas Laschet*** as RBTS' consultant and representation for the regions **Europe, Middle East, Africa** with the following communication details:

Laschet Consulting GmbH · Friedrich-Ebert-Str. 75 · 51429 Bergisch Gladbach · GERMANY
Phone: +49 2204 84-2630 · E-mail: info@laschet.com · Web: **www.laschet.com**

YOUR PARTNER

for Europe & Middle East & Africa

Support for other countries on request.

- **Customer Engineering Support**
  (Rotor Dynamics & Torsional Vibrations)
- **ARMD Software Support**
- **Training Courses & Seminars**

Please contact: **Dr. Andreas Laschet**

Laschet Consulting GmbH

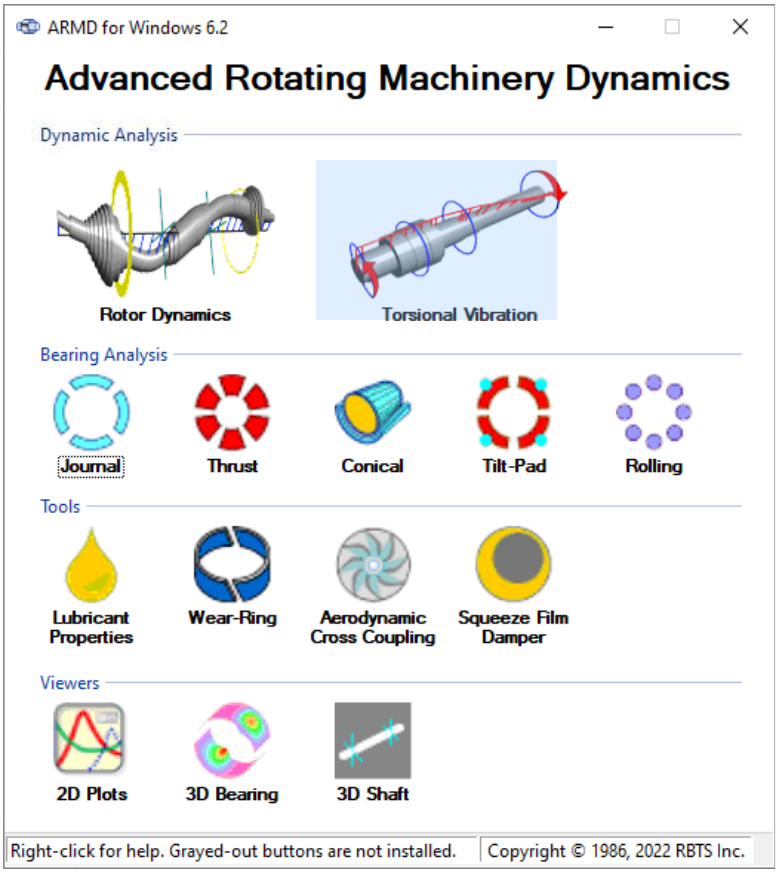
Friedrich-Ebert-Str. 75 · D-51429 Bergisch Gladbach · GERMANY

Ph: +49 2204 84-2630 · E-mail: info@laschet.com · **www.laschet.com**

Advanced
Rotating
Machinery
Dynamics

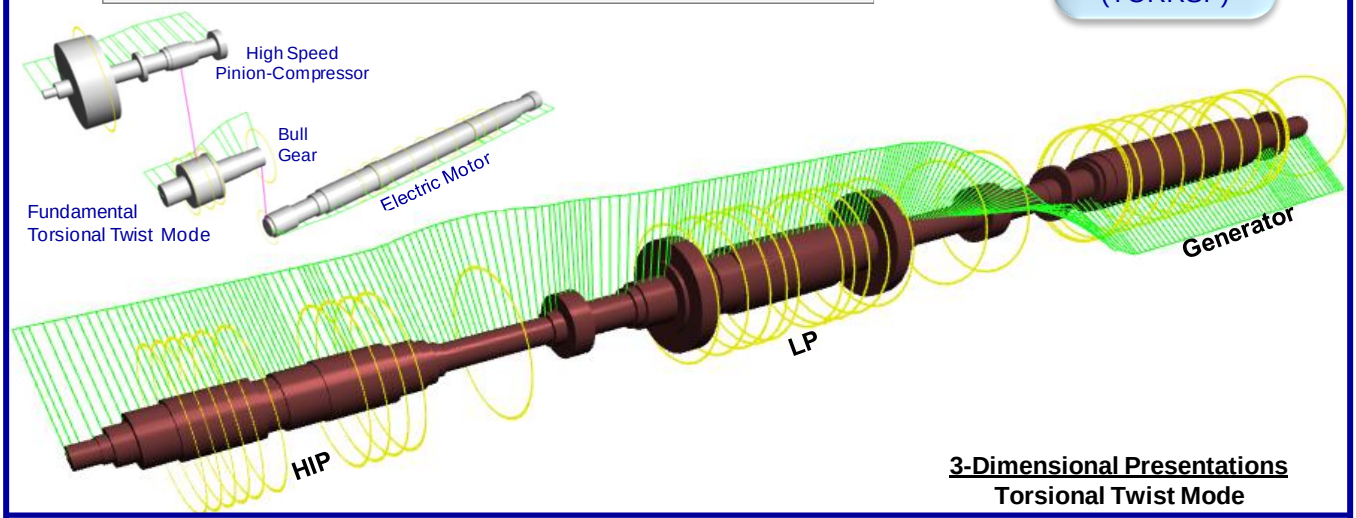
TORSION Version 6.2

New Release



TORSIONAL VIBRATION (TORSION)

- **Natural Frequencies & Mode Shapes** (TORNAT)
- **Steady State Response** (TORHRM)
- **Time Transient Response** (TORRSP)



3-Dimensional Presentations
Torsional Twist Mode

Please contact ***Dr. Andreas Laschet*** as RBTS' consultant and representation for the regions **Europe, Middle East, Africa** with the following communication details:

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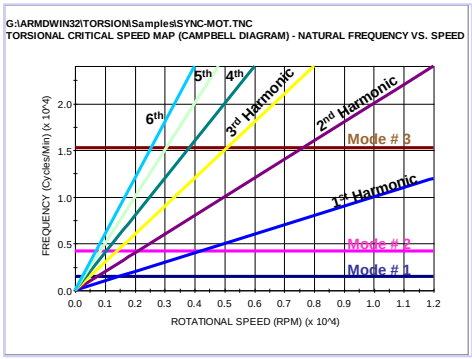
Phone: +49 2204 84-2630 · E-mail: info@laschet.com · Web: **www.laschet.com**

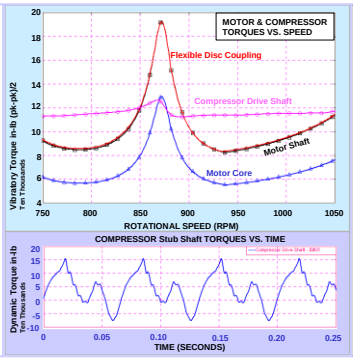
Rev:20230801

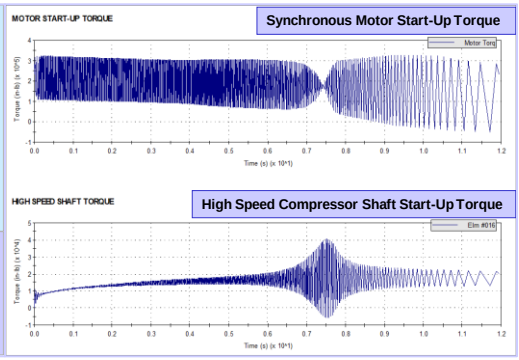
ARMD™ V 6.2 TORSION Package

The Worldwide Leader in Software for Rotating Machinery Dynamics

The torsional vibration package uses a finite-element based formulation for performing damped and undamped torsional **natural frequencies** and **mode shapes** (TORNAT), **steady-state** (TORHRM) and **time-transient** (TORRSP) **response** of mechanical drive trains. The three sub-modules are integrated by TORSION's user interface. The user interface controls the sub-modules to provide a complete torsional vibration analysis environment. TORSION accepts/imports models generated with the rotor dynamics package "ROTLAT" and has advanced modeling features and capabilities including the modeling of multi-shaft/multi-branch systems, coupling stiffness and damping, gear tooth flexibility, stiffness/mass/inertia diameter, torsional springs to ground, various types of external excitations, synchronous motor start-up torque, compressor load torque, user specified time varying torques, electrical faults for motor and generator, and many others.







- *The release of RBTS' **ARMD Version 6 Torsion** is a major milestone in the product's development history, rolling out a **completely new and improved** graphical user interface for the package with enhanced numerical capabilities and features. The software's front end was redesigned with our customers' and industry's input to incorporate the most logical, efficient, and productive techniques to model and analyze complex multi-shaft systems for torsional vibrations.*

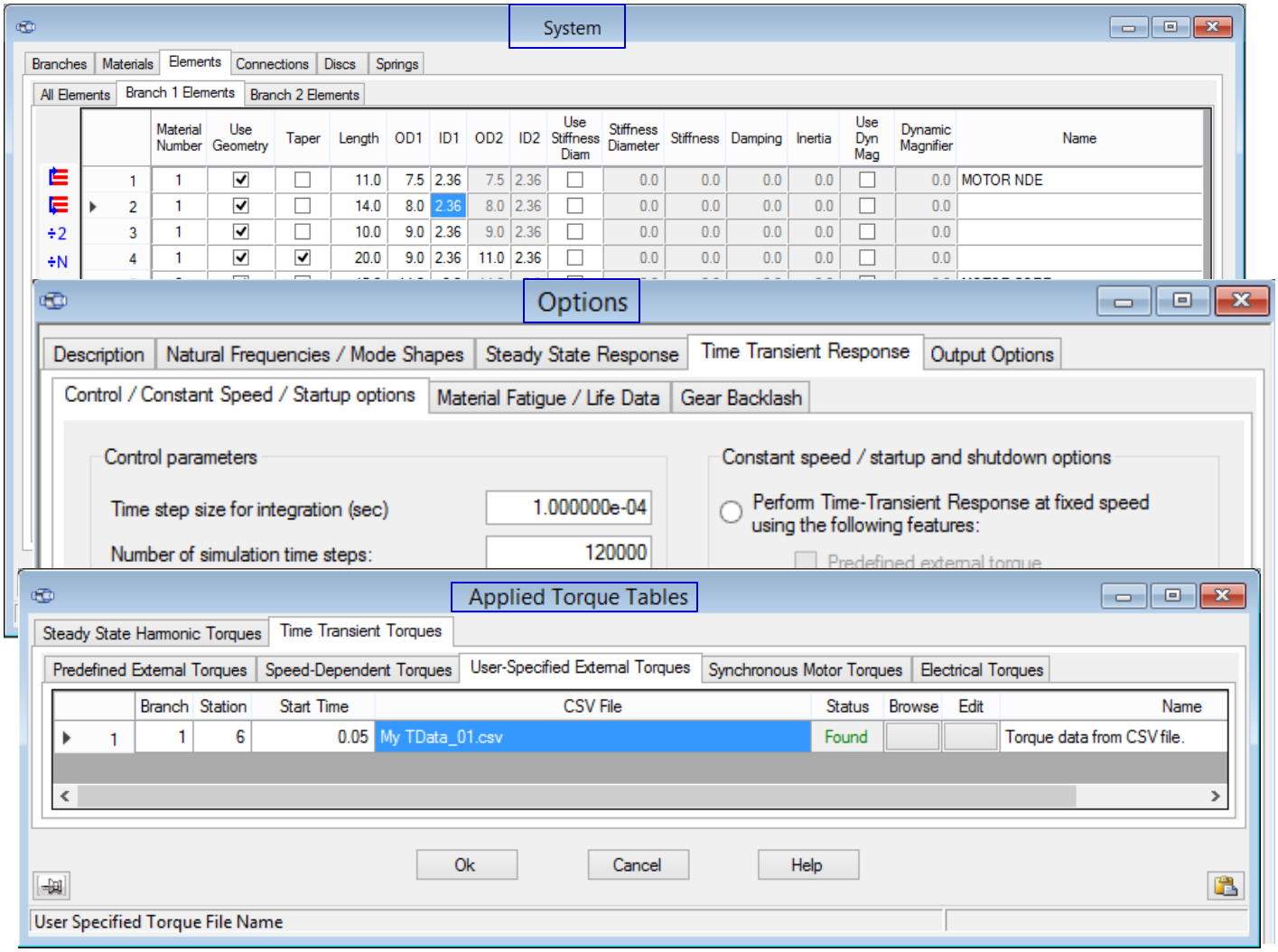
ARMD TORSION users will immediately see the improvements as element, shaft, and system data are presented in a flatter format, with key fields and analysis options readily visible and accessible from the main data entry screens. Engineering productivity to design models is vastly improved as shafts and systems can be easily imported from user-generated component template models. Furthermore, the ability to simultaneously run multiple instances of the program permits rapid side-by-side comparison of results.

By identifying new trends from industry standards, along with RBTS' involvement in turbomachinery standards revisions, new technical features were added to the software. Addition of equivalent torsional stiffness diameters, better handling of shaft connections, expanded user-defined torques application, and better access to temperature dependent properties all combine to provide more accurate modeling and better matching of analysis results to actual system empirical results.

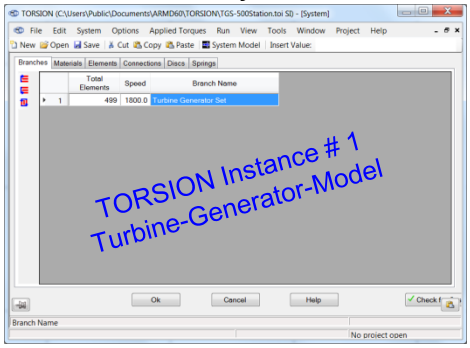
ARMD™ V6.2 – TORSION Package

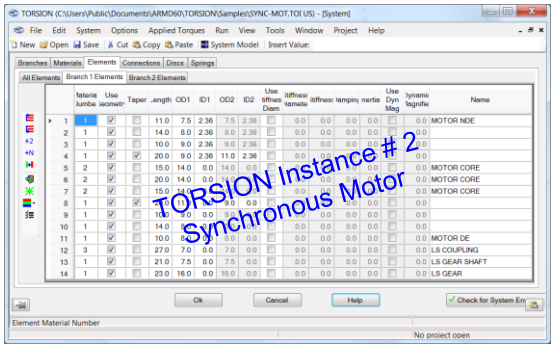
Among The Enhanced Modeling, Usability and Technical Features are:

- **Improved TAB layout**. Redesigned for more direct and faster access to data input locations, and results. - Important functionality is brought forward into the TAB structure, thereby eliminating the need to select from drop down menu lists and mouse right-click drop down menu lists.



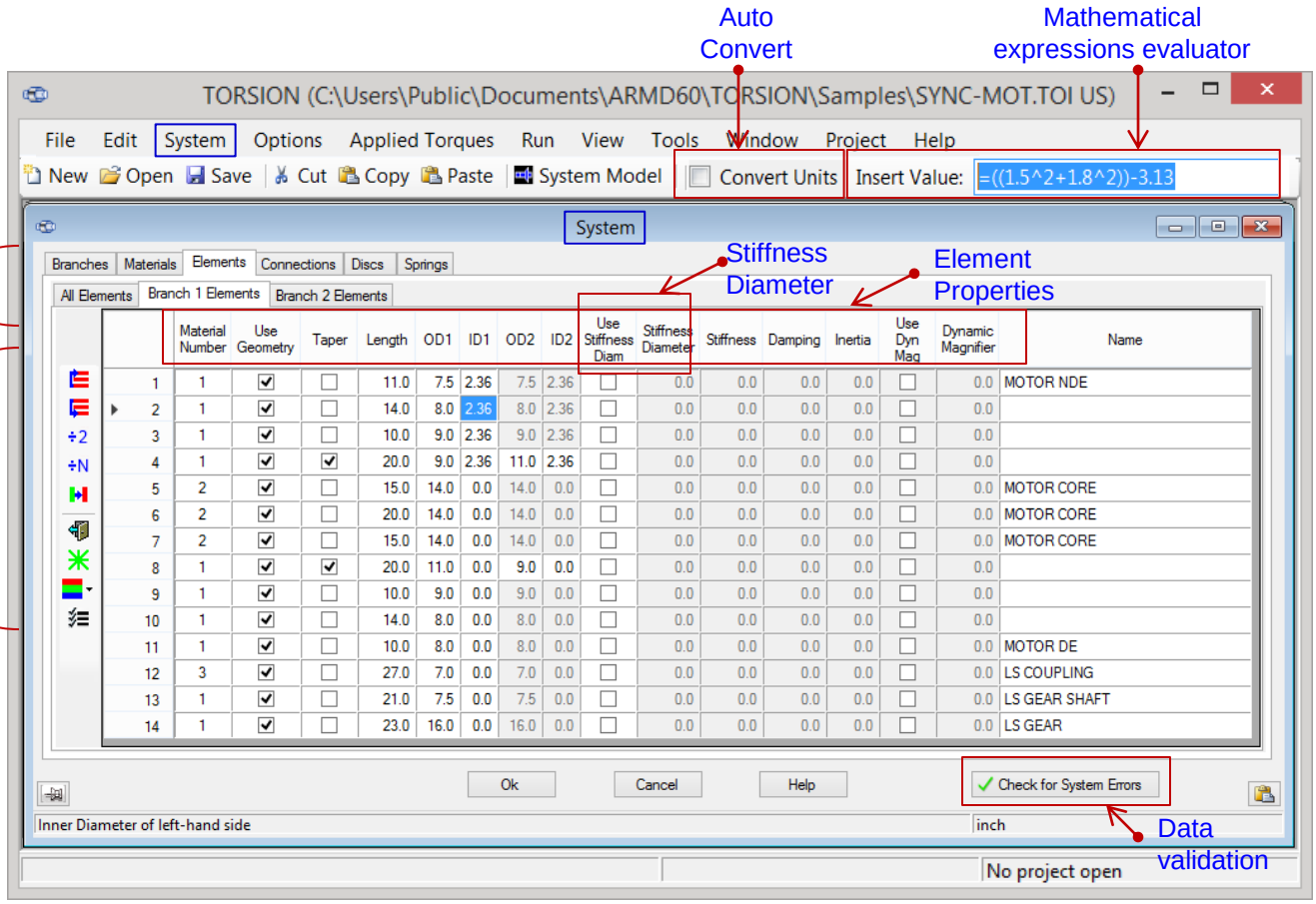
- **Multiple instances of TORSION**. The newly developed package can now **open simultaneously multiple instances of TORSION**, so shafts and component models can be moved easily between different models, also allowing fast, side-by-side comparison of model variations and analysis results. This functionality permits multiple instances of TORSION Version 6 or Version 5.8 to be accessible on your screens.





ARMD™ V6.2 – TORSION Package

Many of the improvements incorporated into the ARMD TORSION Version 6 are specifically directed towards simplicity, increasing usability and increasing productivity as illustrated bellow:



Tool Strip

- Move row Up
- Move row Down
- ÷2 Split Element
- ÷N Divide element into N elements
- Change material
- Undock
- Mark/unmark elements
- Color rows
- Get Summary
- Reverse order of element on a branch

- **Evaluate Mathematical Expressions**. When entering data to cells, data entry field has the ability to evaluate mathematical expressions, without having to launch a calculator app.

- **Whole Number**. Display for improved legibility, defaulting to scientific notation when required.

- **Auto Convert Units**. Automatically computes the units conversion when modeling a system with different components using mixed SI and English units. Example: You have a few inch dimensions to enter amongst hundreds of mm values, just check the box for auto conversion.

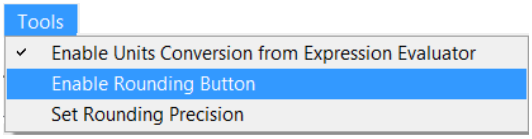
- **Automatic Cell Validation**. Performed at Data Entry time. The program now reviews data grids for incomplete, invalid, or nonsensical entries, providing an Error Flag and correction recommendation. This applies to mass-elastic data fields, user defined torques, and required solver data inputs.

- **Data validation error diagnostics** quickly walks user through any model input errors. A mouse click navigates the user to the next error found.

ARMD™ V6.2 – TORSION Package

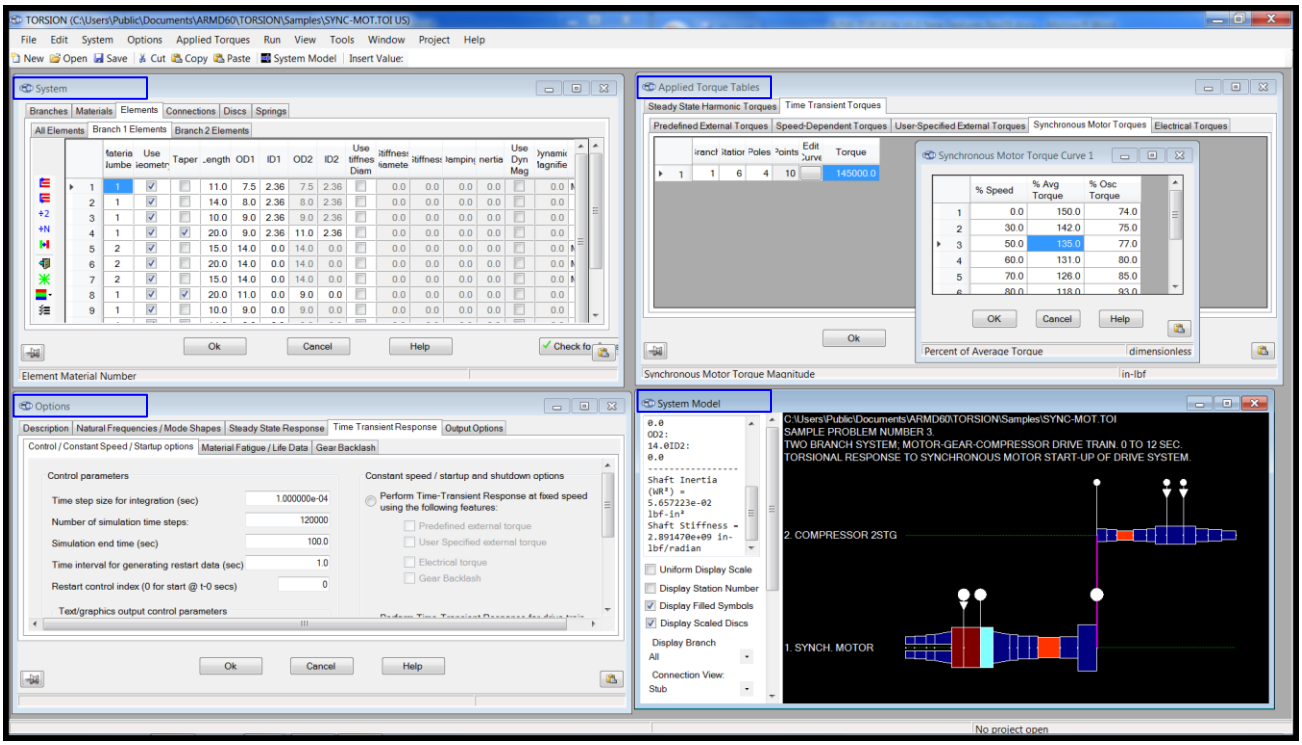
- **Row Tagging**. Row marking/tagging for quick identification and rapid recall, advantageous for multi-shaft systems with very large numbers of elements.

- **Round Function**. Round function for data entry fields is accessible from the Tools menu, and can be declared for all data fields.



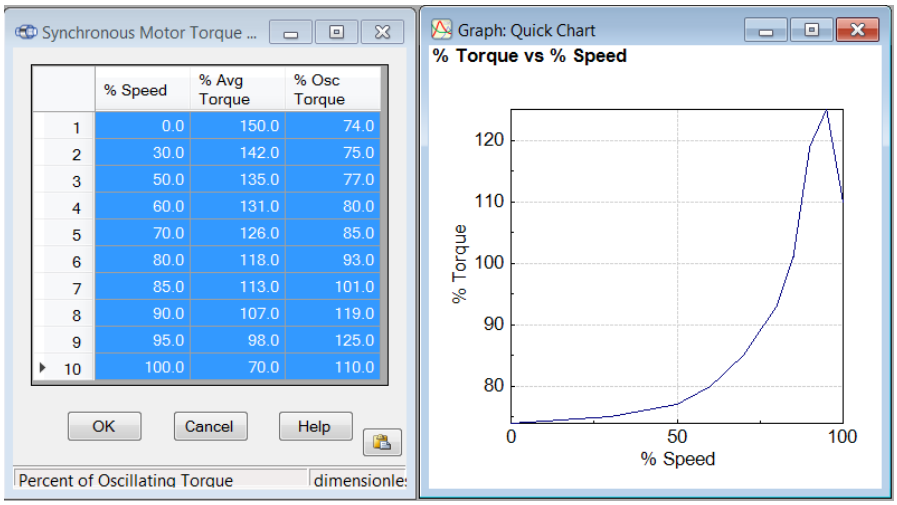
- **Tool Strip/Bar and Buttons**. Replace hidden right-click menus to provide enhanced visibility of functions and features.

- **Data Entry Grids**. All data entry grids can be open simultaneously for ease of model building.

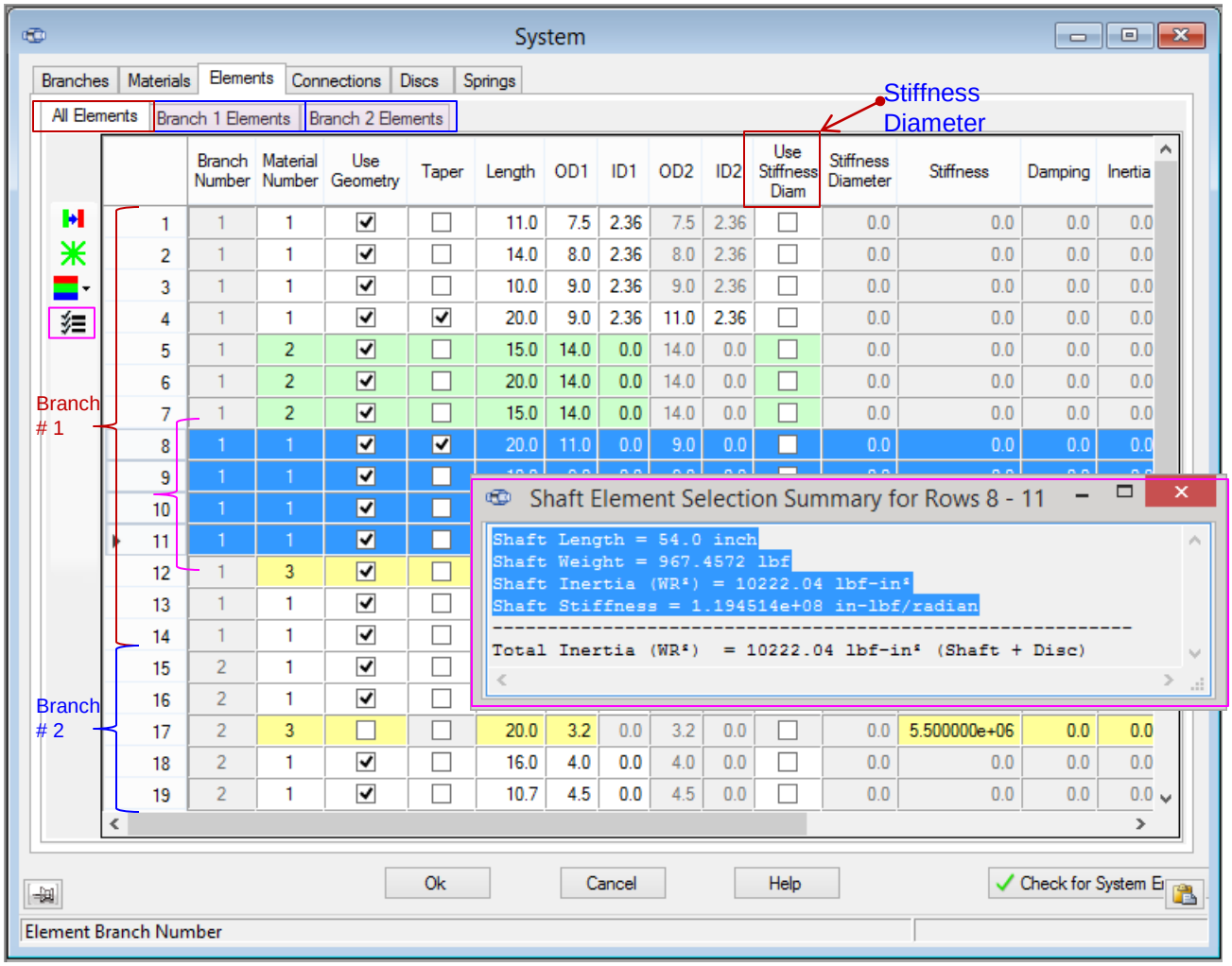


- **Data Entry Menus**. All data entry menus are visible at the Grid input page. Grids now feature selection check boxes and editing buttons where appropriate.

- **One-click Quick Chart**. This feature rapidly displays an X-Y graph of entered tabular data for visual verification of correctness. ARMD Graph software is still available for complete graphic analysis capabilities.

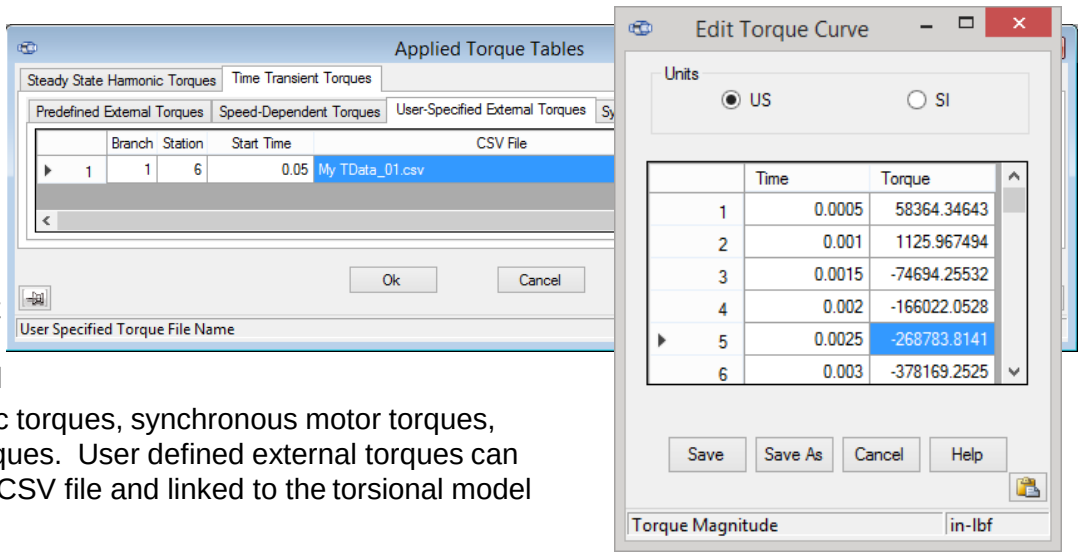


- **All Branches**. All branch element data is presented on a single grid form allowing simultaneous access to all branch elements of a multi-branch system. This new presentation is much more user efficient for data entry and multi-branch model review.

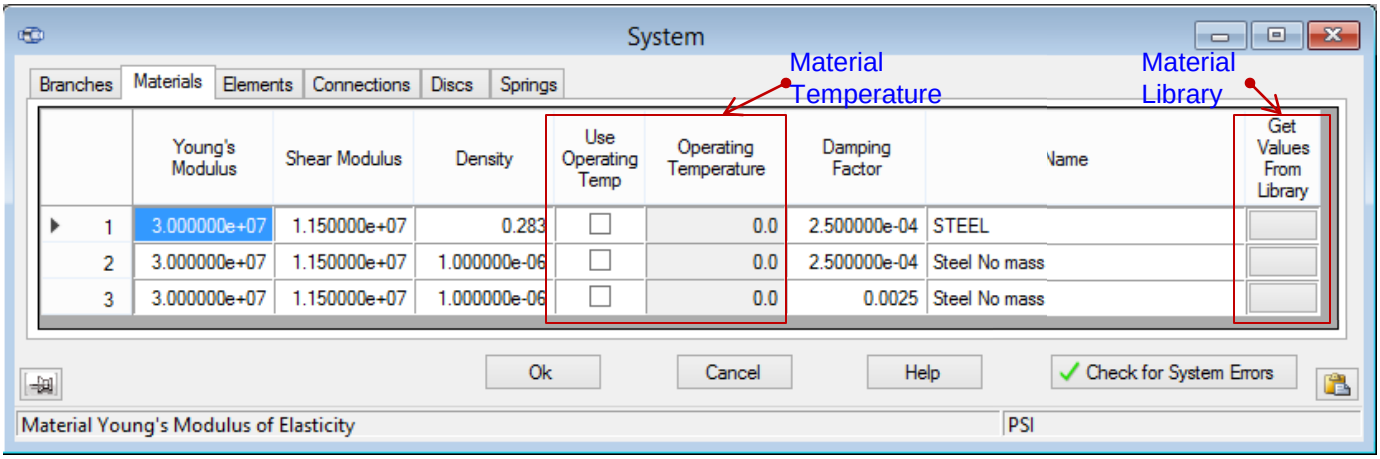


- **Stiffness Diameter**. Can be used to enter the equivalent mass-elastic properties of complex shaft sections, motor lamination stacks, shrunk on disks, etc.

- **Time-Transient User-Defined Torques**. User has complete freedom to specify, including predefined external torques, speed dependent torques, user-specified external torques, harmonic torques, synchronous motor torques, and electrical torques. User defined external torques can be prepared in a CSV file and linked to the torsional model as shown here.

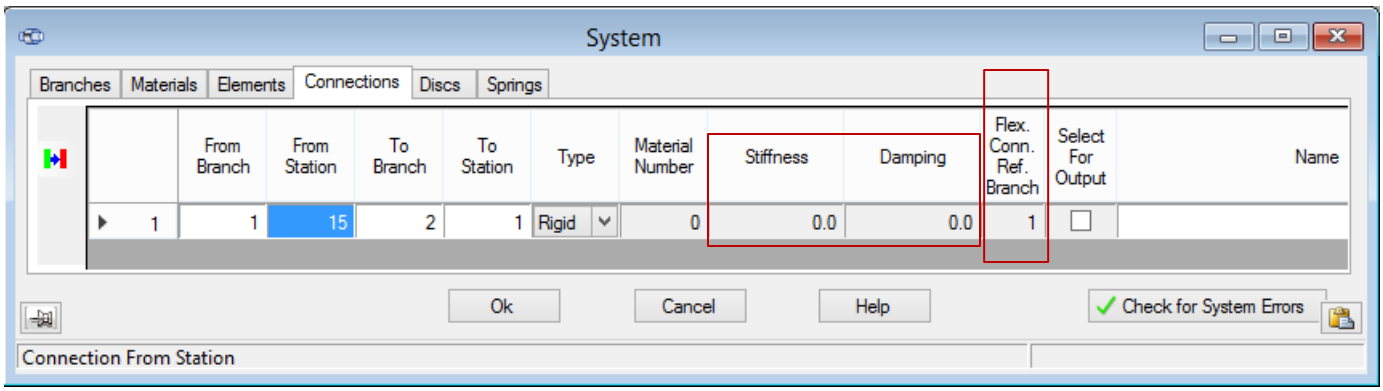


- **Shaft Material Temperature**. Material operating temperature is readily input and enabled, to capture the temperature dependent material properties and the effects upon torsional modeling. Particularly useful for shafts in high temperatures applications like steam turbines, rolling mills or extruders.

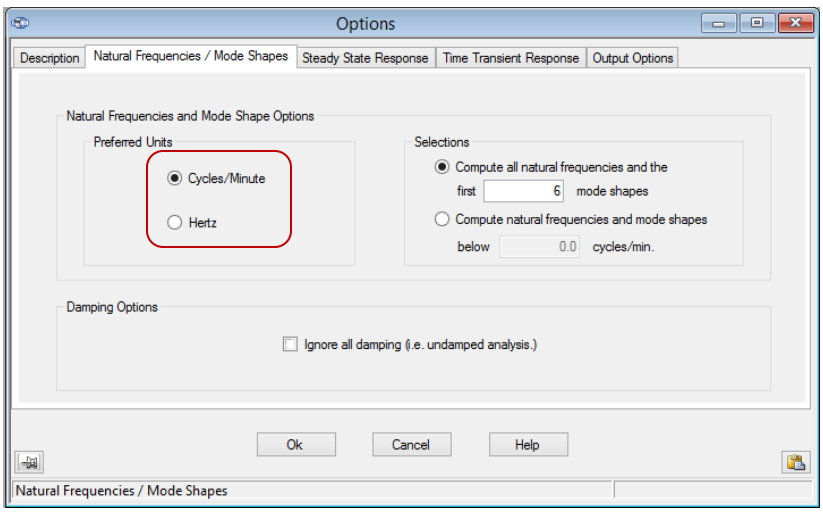


- **Shaft Connections**. Better handling of shaft connections for multi–speed systems. The reference shaft and its associated speed are selectable, allowing the analysts to see speed-based variable-stiffness effects upon the model.

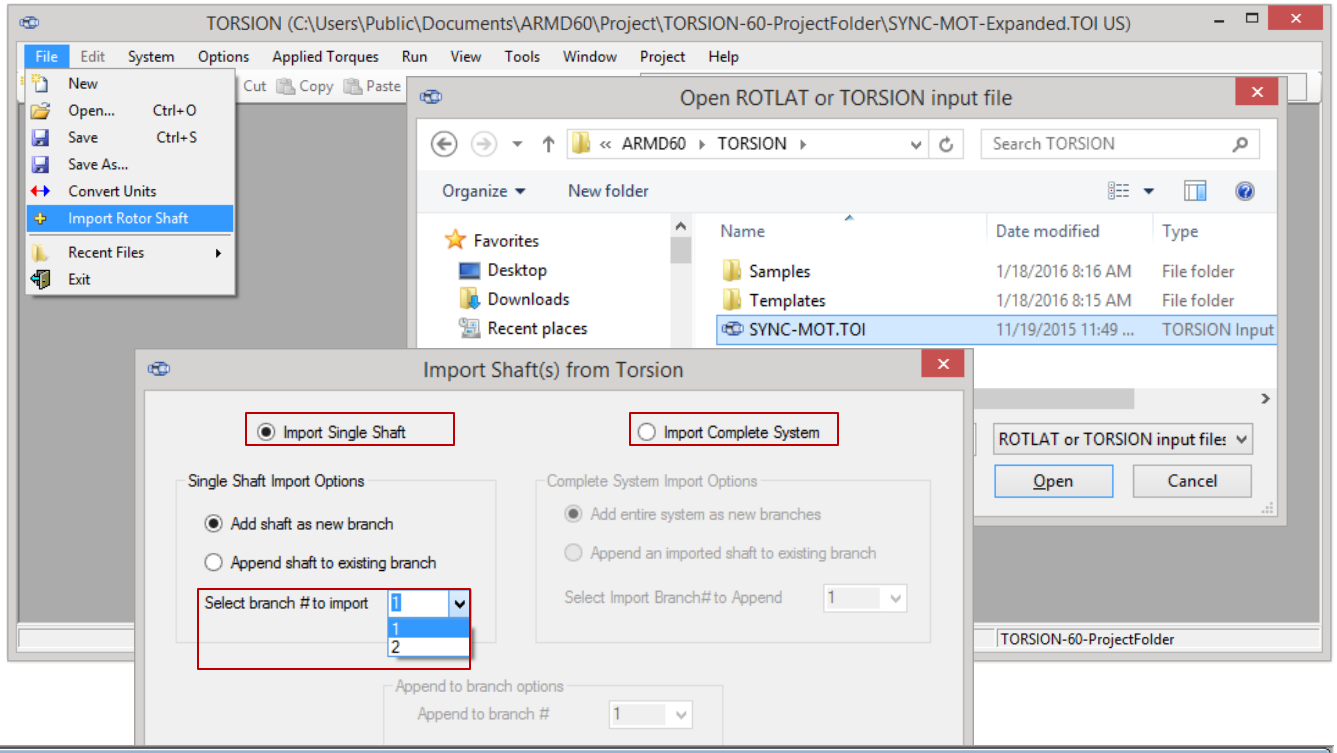
- **Shaft Connections Specification Form**. Optional full linear connection display between shafts with the ability to specify stiffness and damping values, all on one form.

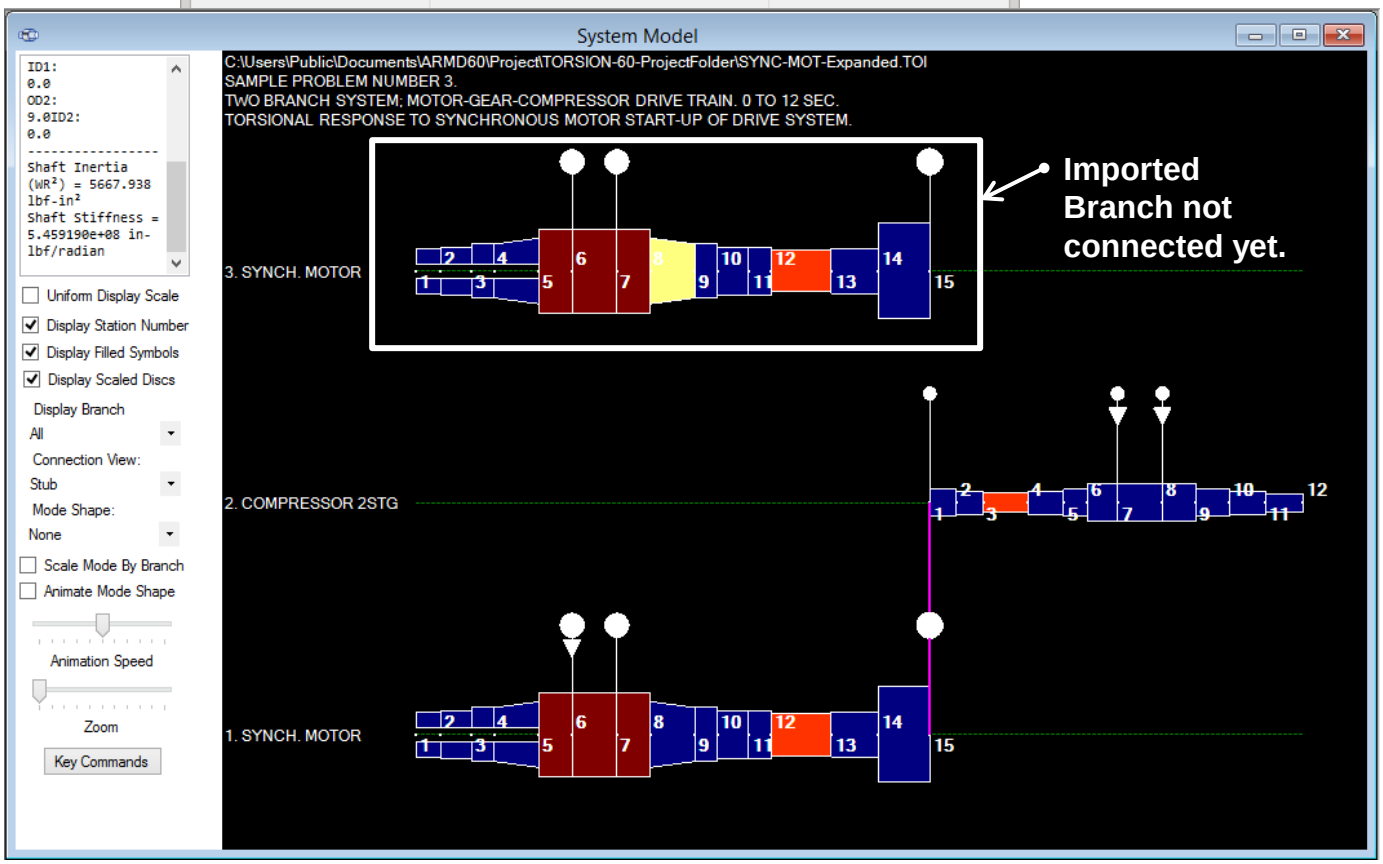


- **Selectable Output Units**. Selectable Frequency Units between CPM or Hz, in accordance with the user's preference, or the industry standard format can be set simply by checking a box in the options form.



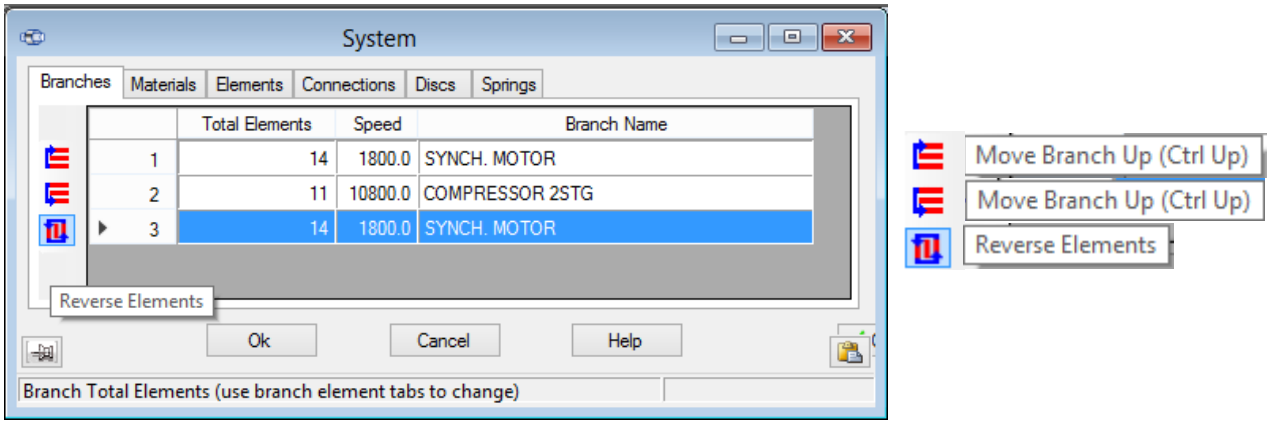
- **Import of Models**. Import a complete TORSION multi-shaft system or only a single shaft from another TORSION input file. Imported shafts can be included on new system models either by inserting into a shaft, or appending to a shaft model. A powerful modeling tool to efficiently model like or similar systems in rapid fashion.



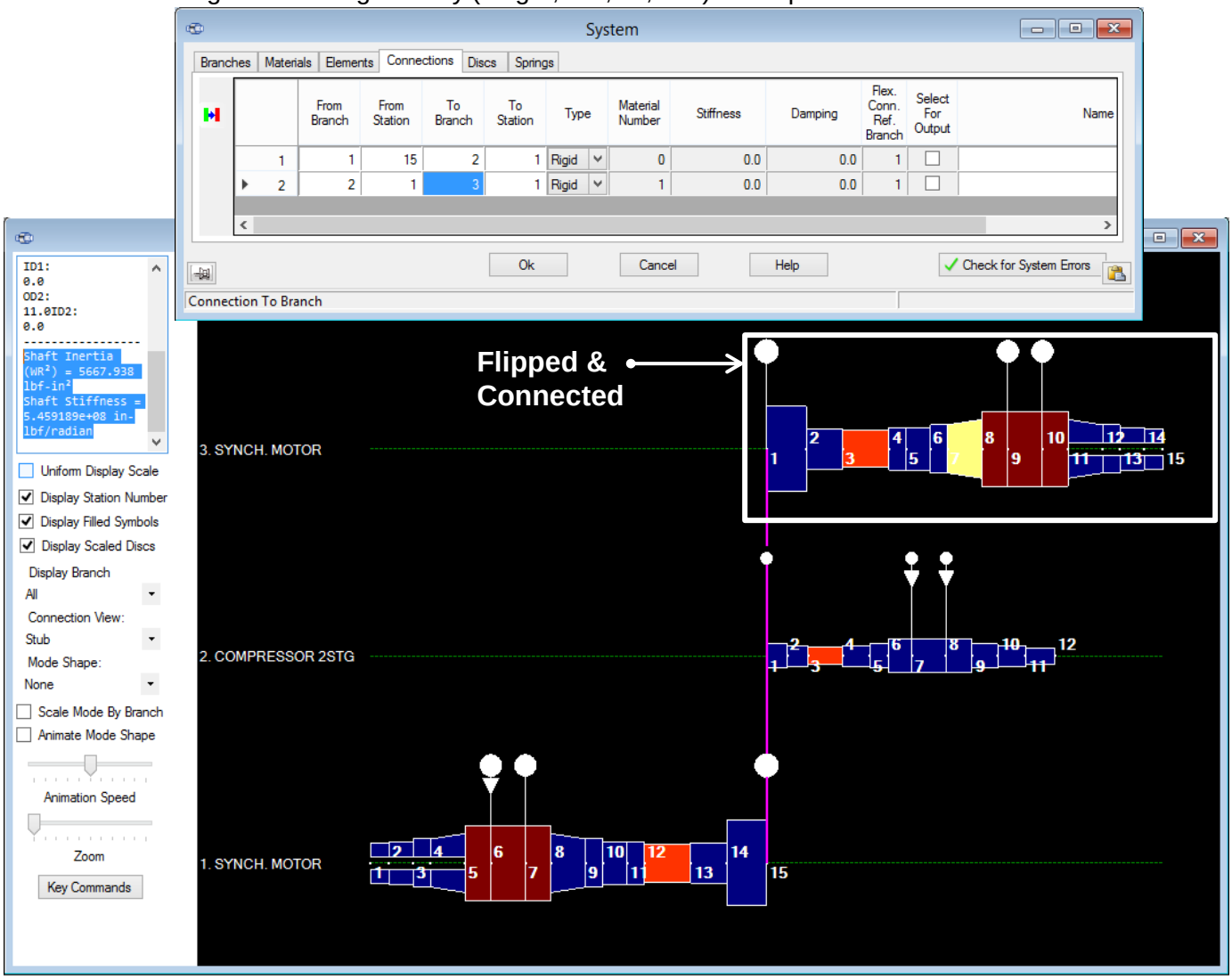


➢ **Import of Models** (continued).

- Shaft models can be **flipped from left to right** with a single button click.

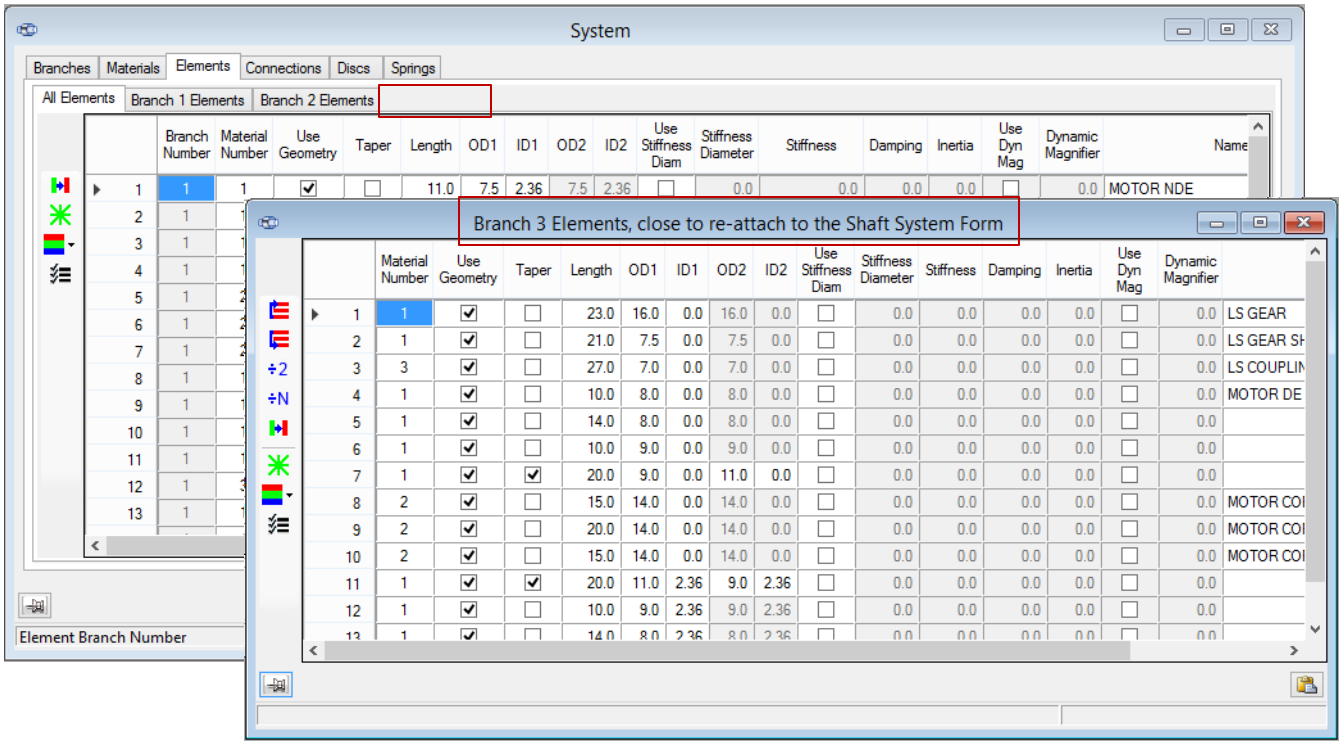


- Shaft models can be **moved up or down** in the system model with a single button click.
- Shaft elements can be **moved along the shaft in either direction** with a single click.
- Shaft elements can be **divided** into a user specified number of smaller elements, while retaining the overall geometry (length, OD, ID, etc.) in the process.



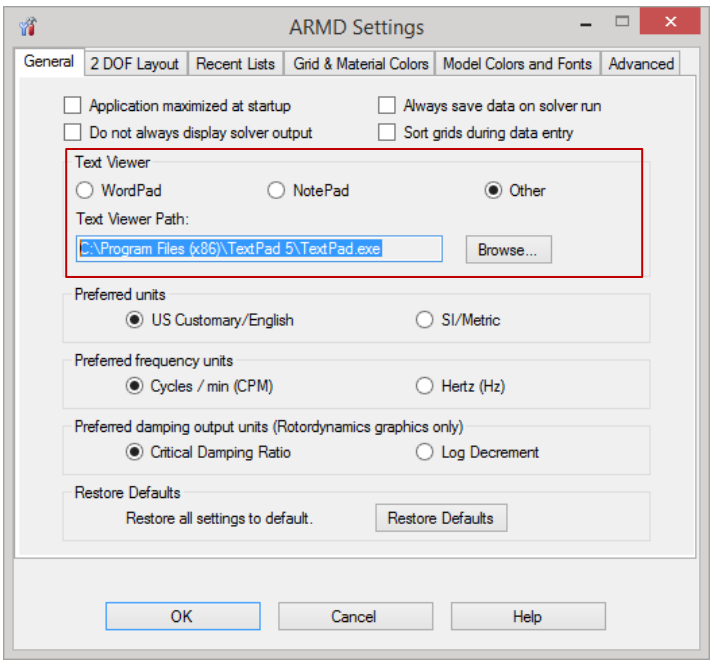
➢ **Import of Models** (continued).

Shaft element **data entry grids can be detached** from the System Form to allow multiple shaft element grids to be modified concurrently.



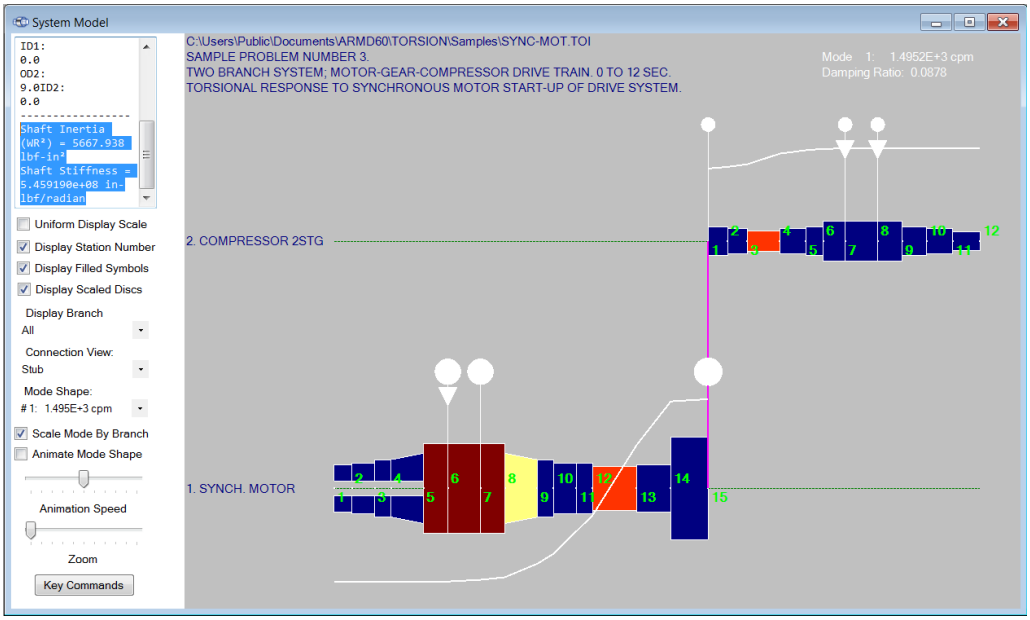
➢ **Create Templates** . Templates can be created for shaft component assemblies for TORSION model input files, allowing for quick access to, and rapid construction of, new multi-shaft systems.

➢ **Text Output Viewer**. User selectable text output viewer that can be Word, Open Office Writer, Notepad, WordPad, or any other program which accepts text file input. Setting are specified in the ARMD Settings form from the help menu.



➢ 2-D GRAPHICS MODEL.

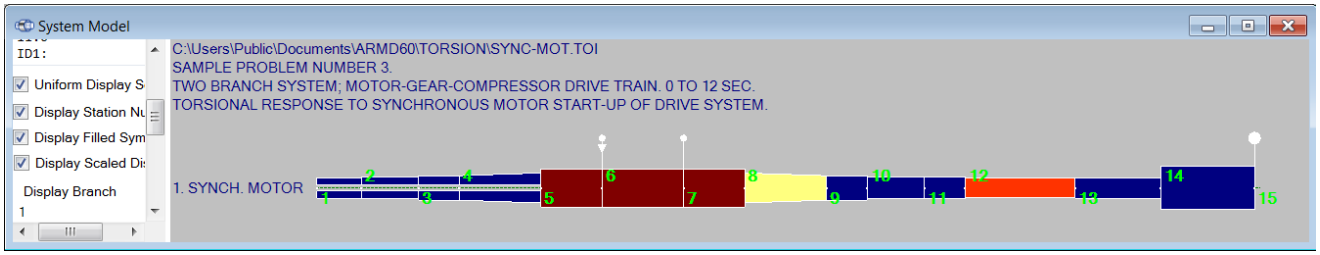
Real-time graphics update of the 2-D image corresponding to numeric data input in data grids provides visual confirmation of model correctness while building system models.



2-D Model auto resizing gives user the option to "fit-to-page" complete models or single branches. User can automatically view the model with the correct aspect ratio, thereby permitting rapid, visual model review.

2-D model viewer mode options now include:

- Single Branch View.
- Auto Scale to Width for the complete model or a single shaft.
- Stub Shaft View to represent large, multi-shaft models in a simplified fashion.
- Auto Aspect Ratio presentation.



Interrogate an element using the 2-D Model Viewer to see all defining element data in a side-bar data window.

Element selection with control keys within the 2-D model viewer permits easy identification of particular cells within large models. This is useful for closely spaced, thin elements.

Rotated view option for copying the 2-D model graphic to the clipboard.

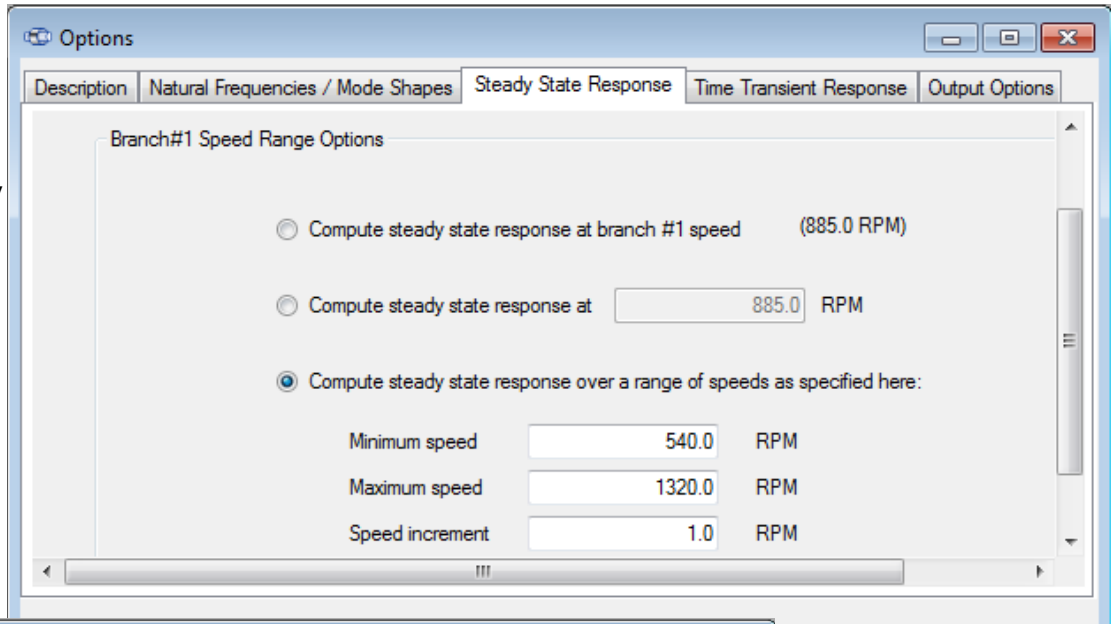
Metafile enabled copy and paste of system models and graphics for better report graphics.

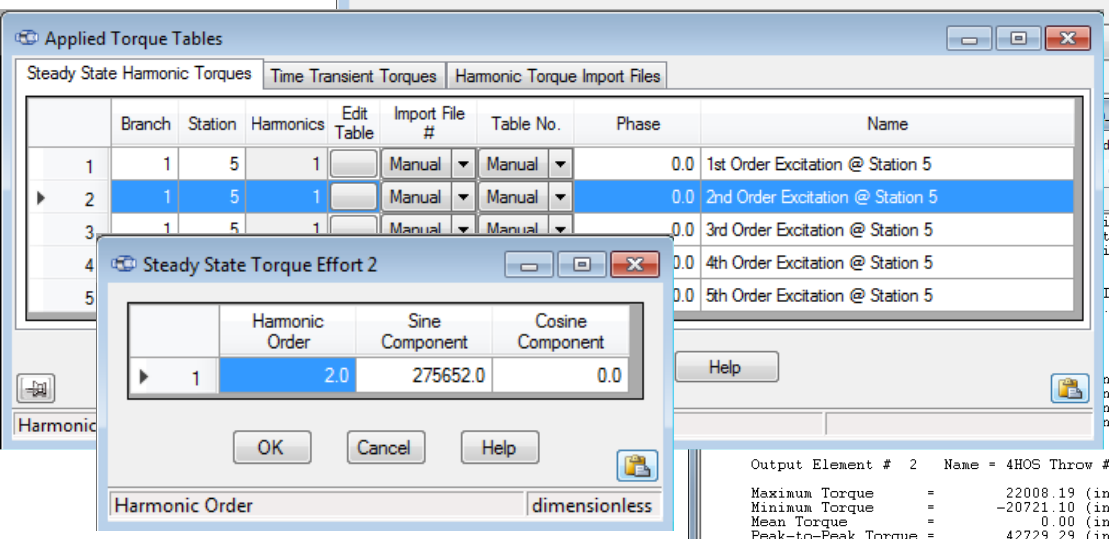
Tool panel has been added on the 2-D display window for enhanced graphics control and better visibility of display options.

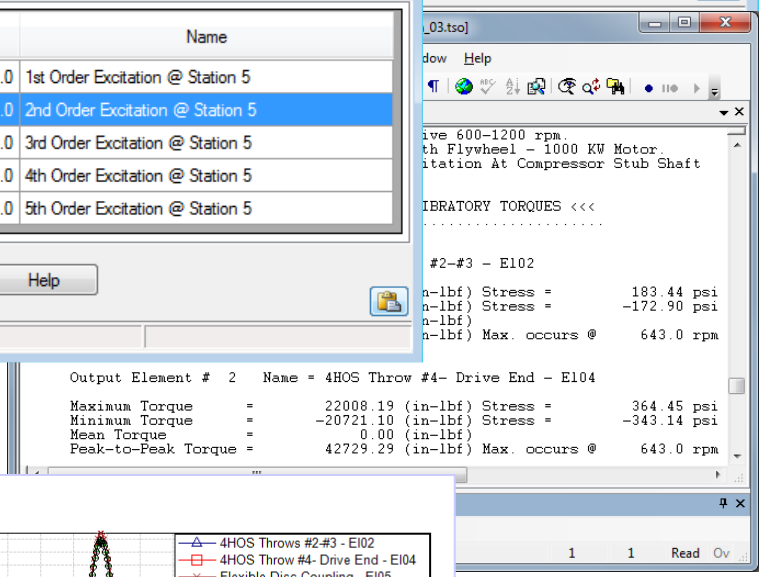
ARMD™ V6.2 – TORSION Package

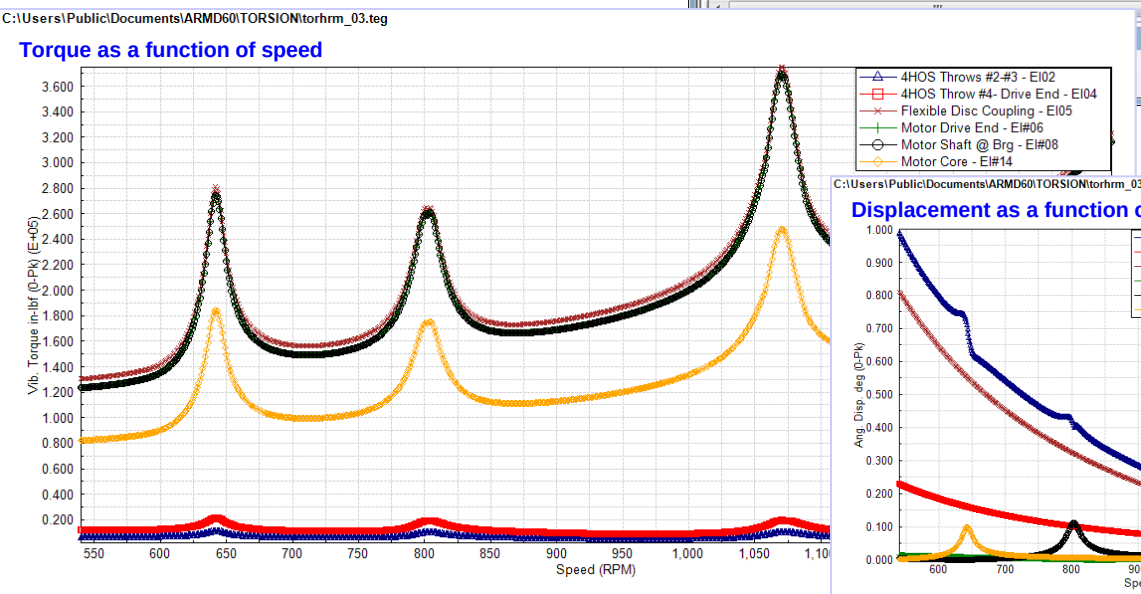
- **Steady State Response.** Performed at specified speed or as a function of speed with any harmonic excitation at any shaft location.

  Results include element torques & stresses, station angular displacement, velocity and acceleration, etc.

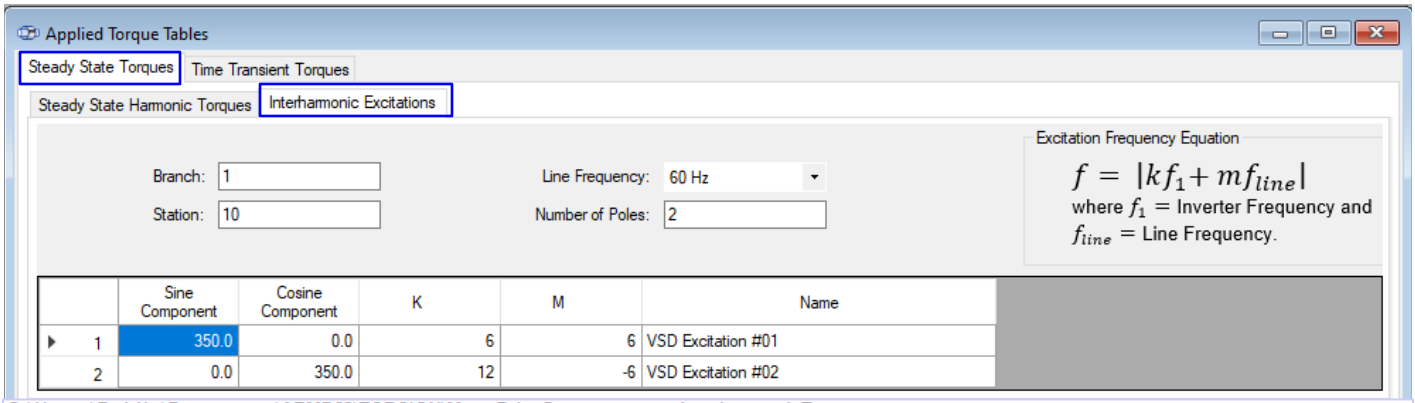


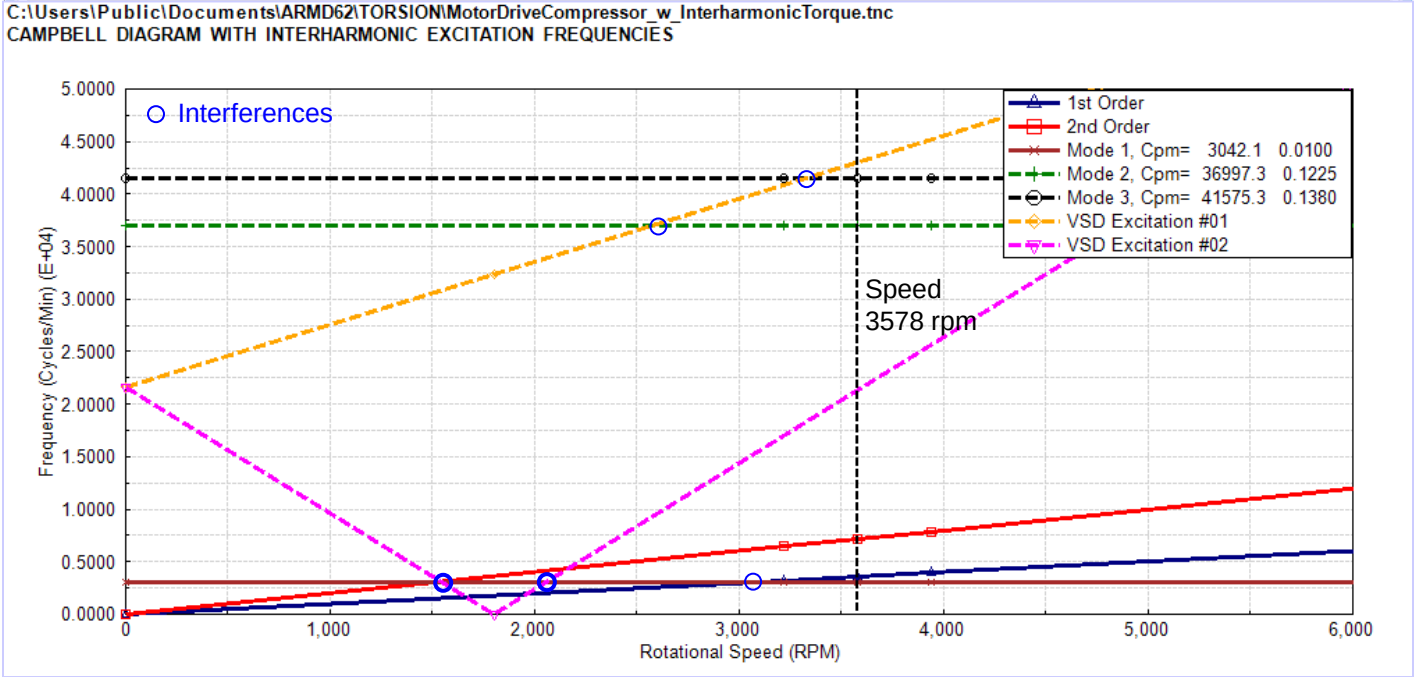


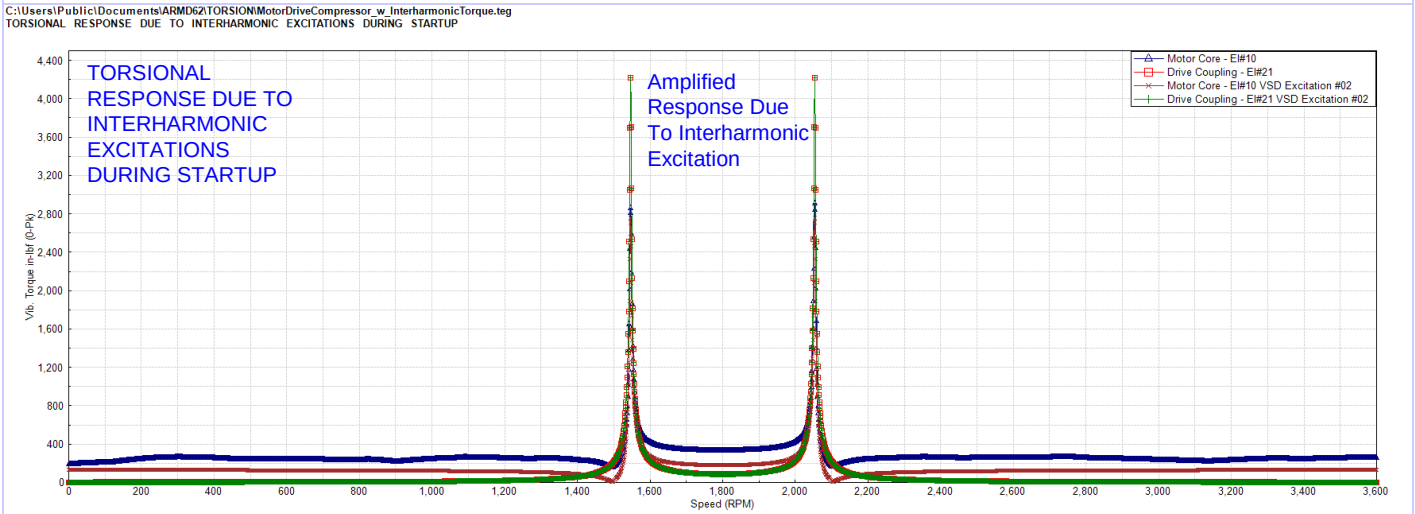




- **Steady State Interharmonic Excitation & Response.** Electric motor controllers used in variable-speed drive (VSD) applications generate integer and non-integer harmonic torsional excitations. Intersections between these harmonic excitations with relevant torsional natural frequencies can create "troublesome" levels of resonant response and, therefore, must be considered. ARMD's TORSION software module provides a complete evaluation of VSD-related harmonic excitations.







ARMD™ V6.2 – TORSION Package

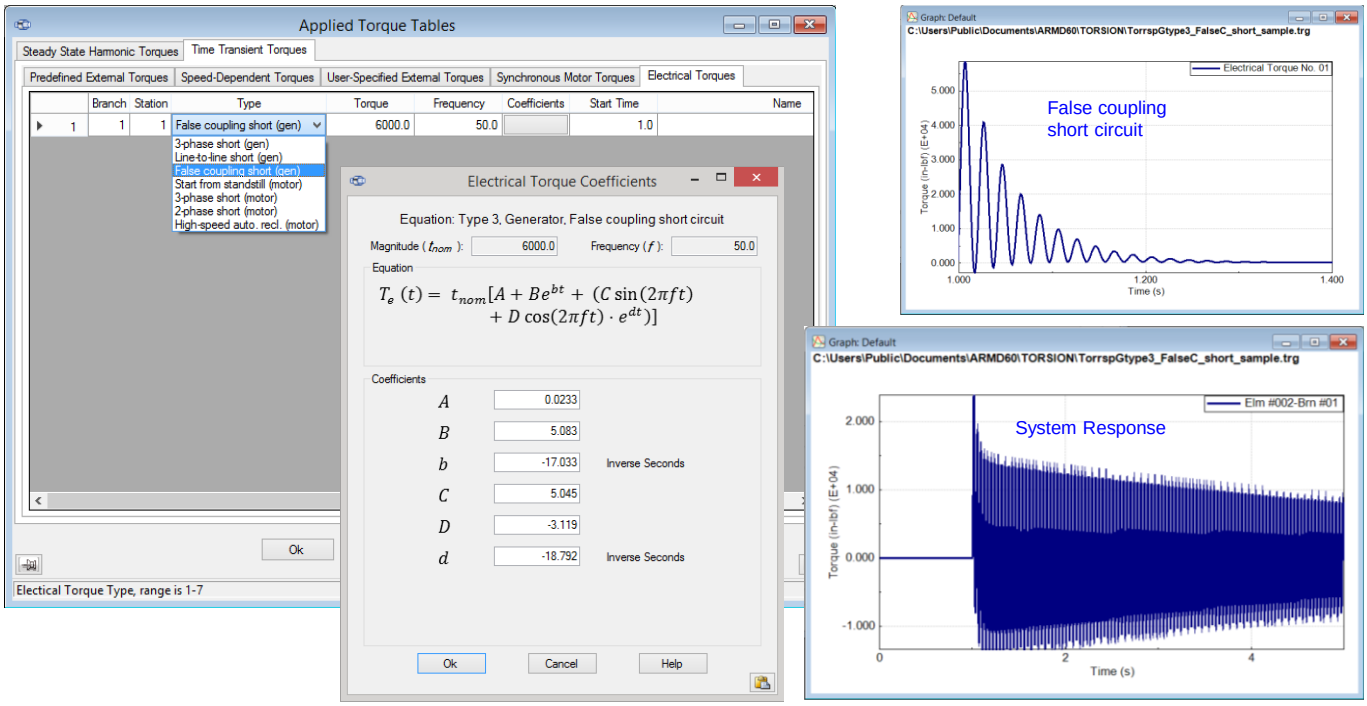
➢ **Generator/Motor Electrical Excitations**. Among the features incorporated in TORSION package are electrically-induced, time-varying exciting torques associated with generator and induction motor operation that include:

Generator

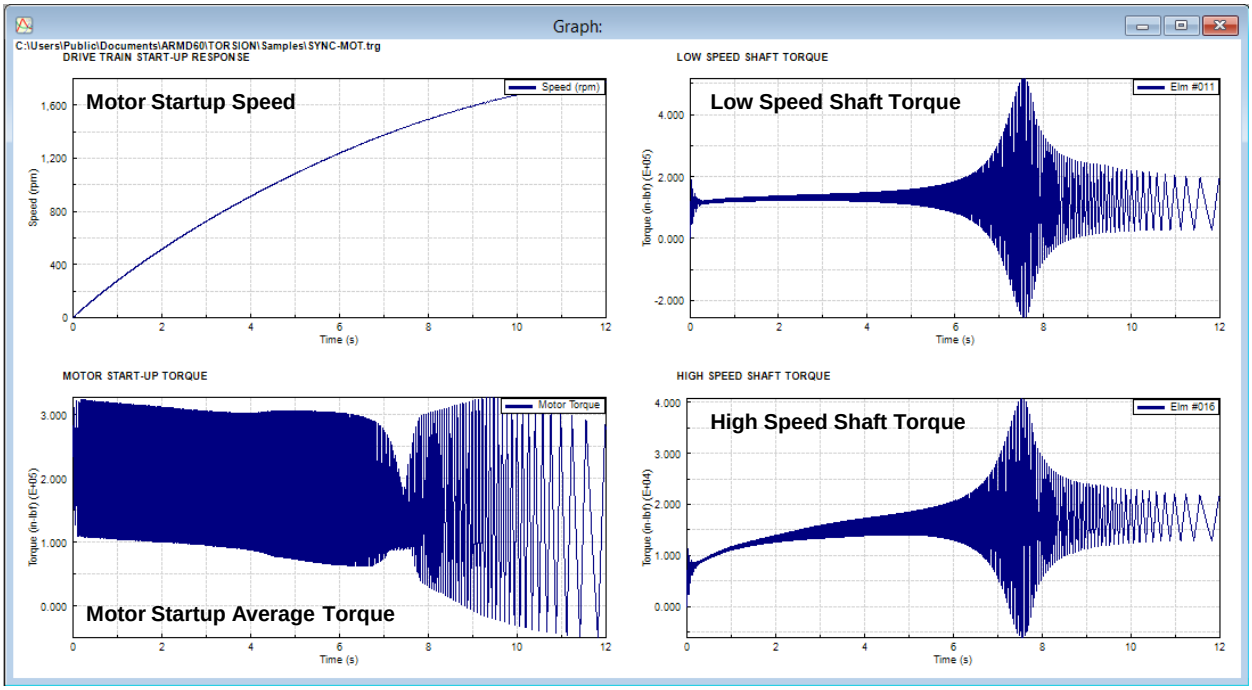
1: 3-phase short circuit
2: Line-to-line short circuit
3: False coupling short circuit

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

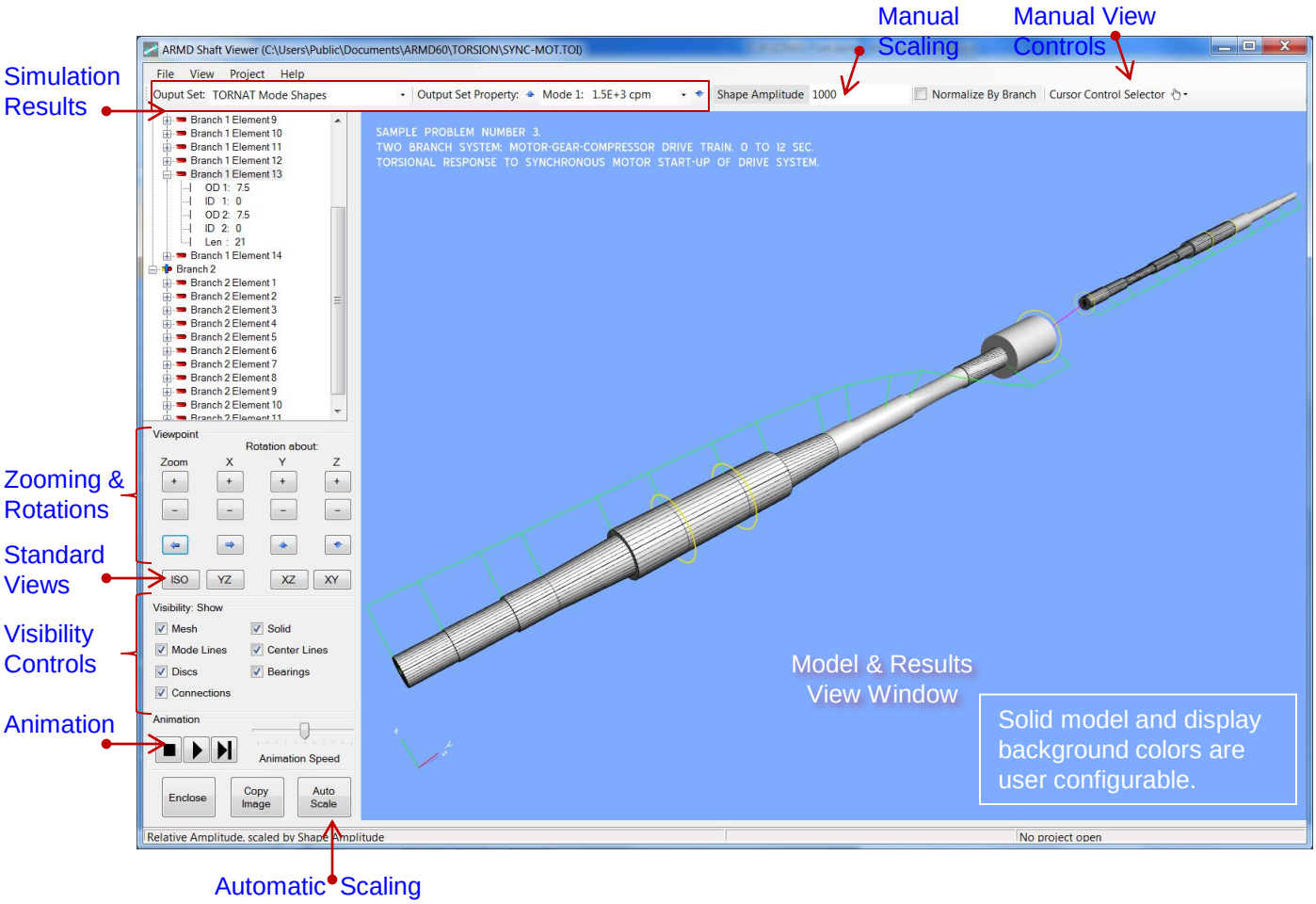


➢ **Startup characteristics** of synchronous motor, user-specified time-transient external-torques, & calculated system response torques are available in the graphics output file.

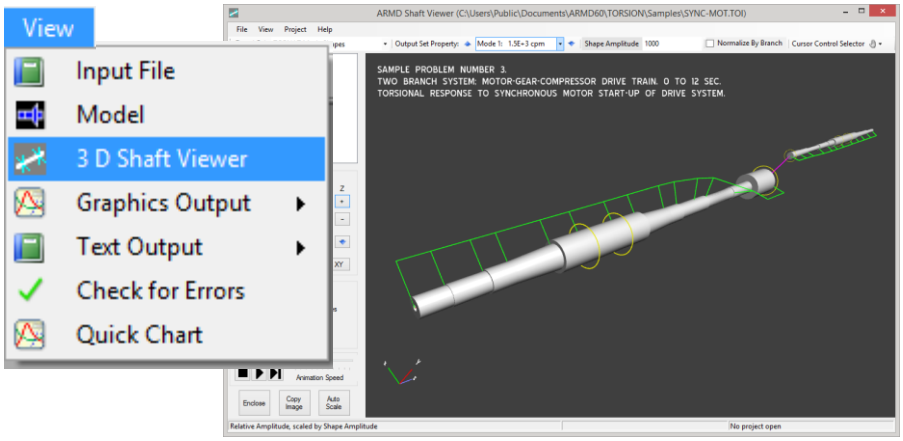


3-D Shaft Viewer Utility (ARMDShaftViewer)

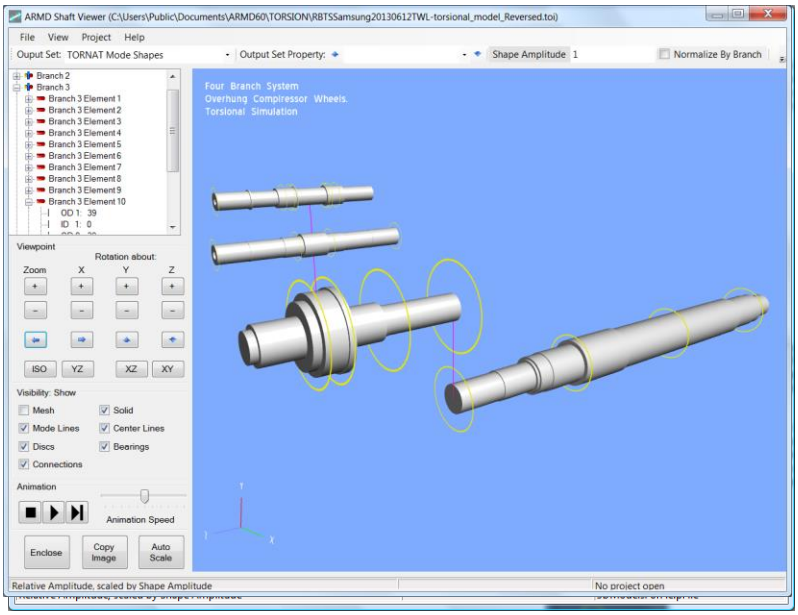
ARMD Shaft Viewer is a 3-D rotor system graphics utility integrated in the ARMD suite. It uses modern 3-D graphic rendering technology to provide a highly realistic view of rotating assembly models and drive train system models. In addition, dynamic performance results generated by the rotor dynamics module ROTLAT and torsional vibration analysis module TORSION can be presented. Displayed models and their dynamic performance results can be rotated, zoomed, moved and animated to provide the user with an efficient and enhanced view of the system dynamic characteristics. The ARMD Shaft Viewer **workspace** is shown below.



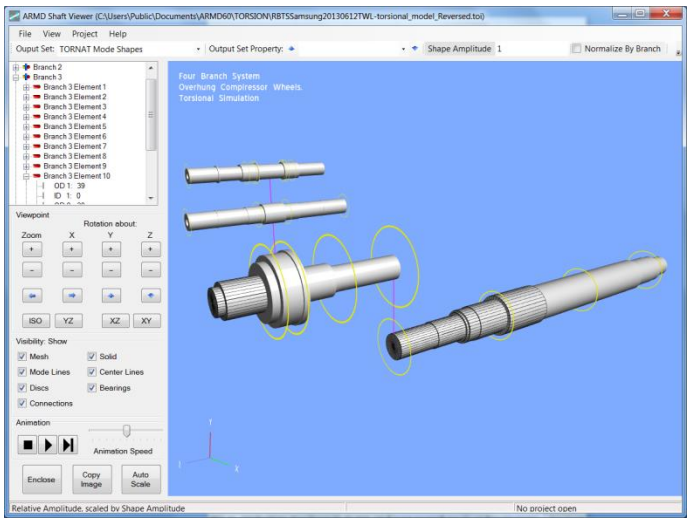
The Shaft Viewer can be run as a stand-alone display utility either from the ARMD main menu or from the computer's Start menu. It is also fully integrated into the ROTLAT Rotor Dynamics and TORSION Torsional Vibration modules, where it is automatically loaded/accessed via the View menu.

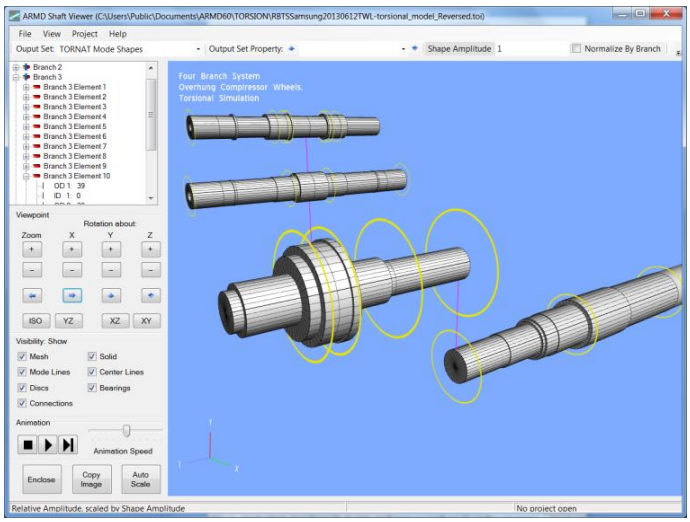


The default opening view is isometric (ISO). Viewpoint is modified using the buttons for zooming and rotation on the left side of the display. By pressing the + and – buttons, the display can be zoomed or rotated about any of the three axes. The arrow buttons in the middle of the Viewpoint group move the display left, right, up, and down. Continuous motion can be achieved by holding any of the arrow buttons down. The display can be reset at any time to one of 4 standard viewpoints, the default ISO view, or projections on the YZ, XZ, or XY planes. The Enclose button re-centers the model without changing its orientation.



Various elements of the model can be selected for display using the check boxes in the Visibility control group. When Solid and Mesh items are selected, the viewer performs an automatic level-of-detail (LOD) calculation to determine when the mesh is too dense. If required, the software then suppresses the mesh display automatically.

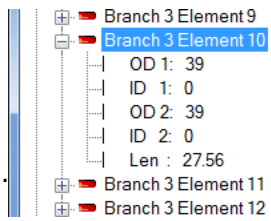


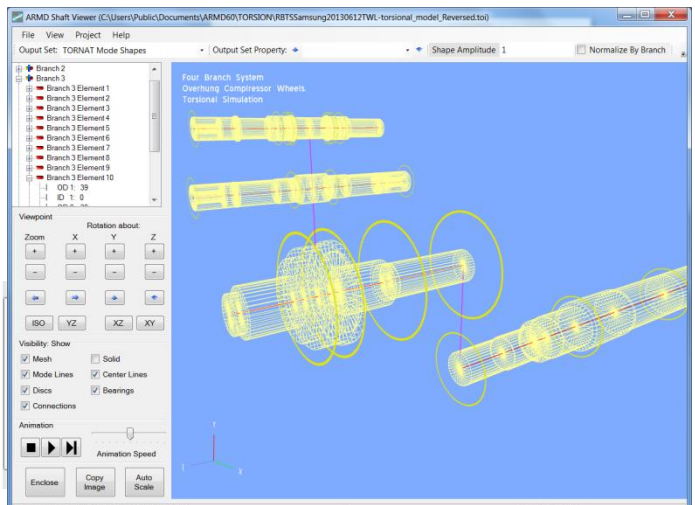


The screens shown above and to the right, first show the mesh suppressed on part of the model followed by full mesh as we zoom in.

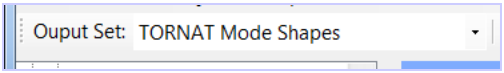
If the solid display is not selected, but the mesh is, then the LOD calculation is not performed and the mesh is shown for all elements.

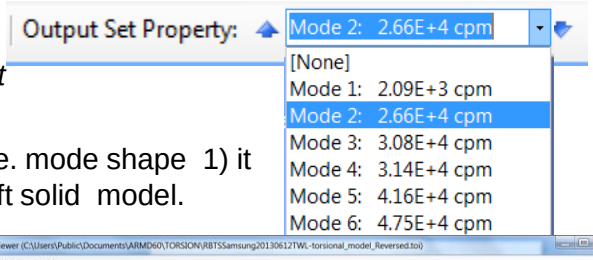
Shaft element information can be found in the shaft element display when an element is selected.



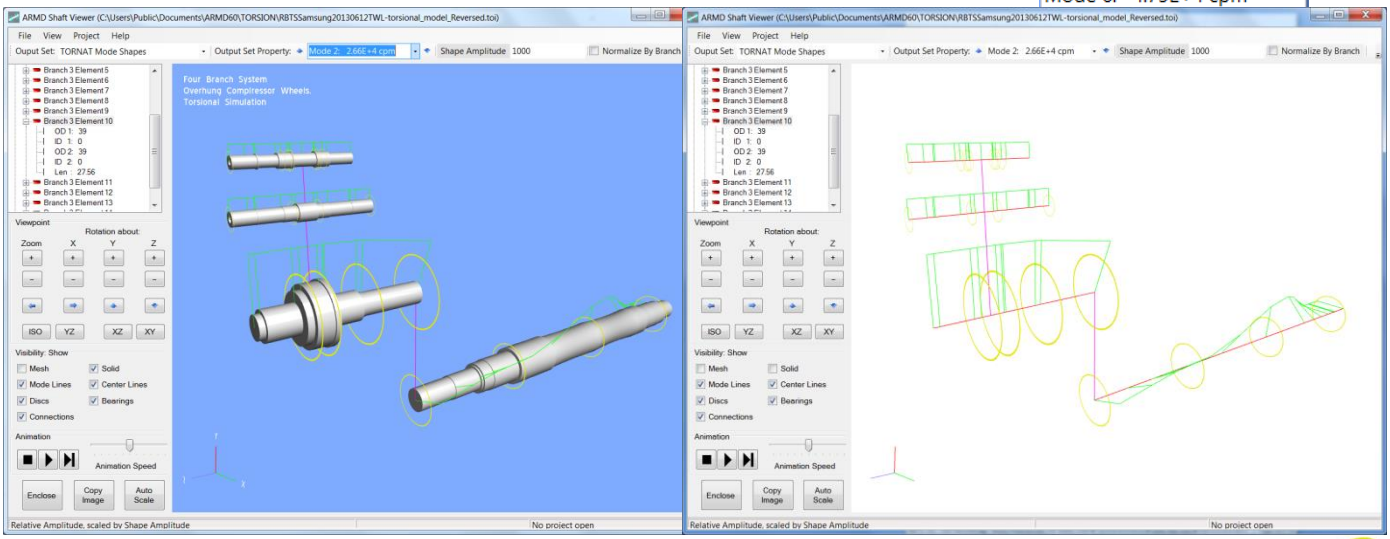


Among the main features of the Shaft Viewer is its ability to display and animate the motions calculated by the various ARMD solvers. When the Shaft Viewer loads a ROTLAT or TORSION shaft system model, it automatically looks for supported solver output files. No user interaction is needed. These output sets are then presented to the user for display in the *Output Set Property* drop-down box on the viewer's main toolbar.

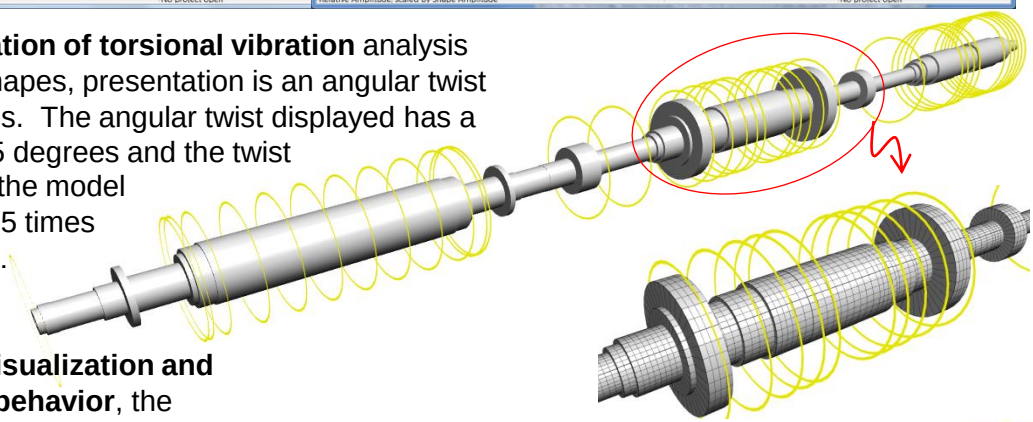




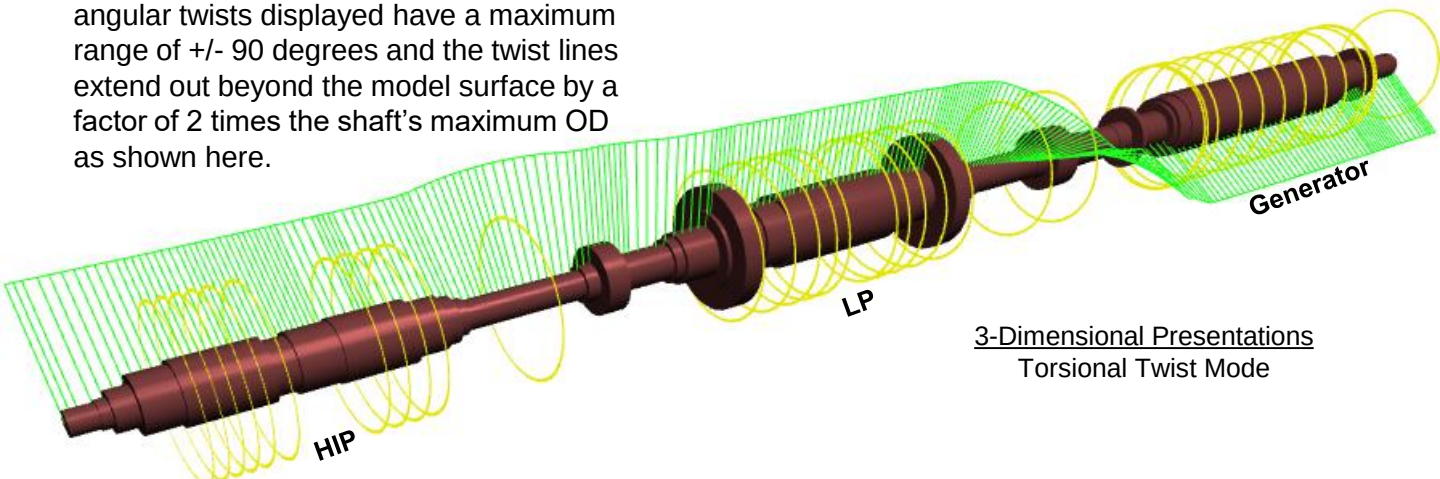
Once an output set and property has been selected (i.e. mode shape 1) it is displayed as shown below, with and without the shaft solid model.



For enhanced visualization of torsional vibration analysis results, such as mode shapes, presentation is an angular twist about the rotational Z axis. The angular twist displayed has a maximum range of +/- 45 degrees and the twist lines extend out beyond the model surface by a factor of 1.25 times the shaft's maximum OD.



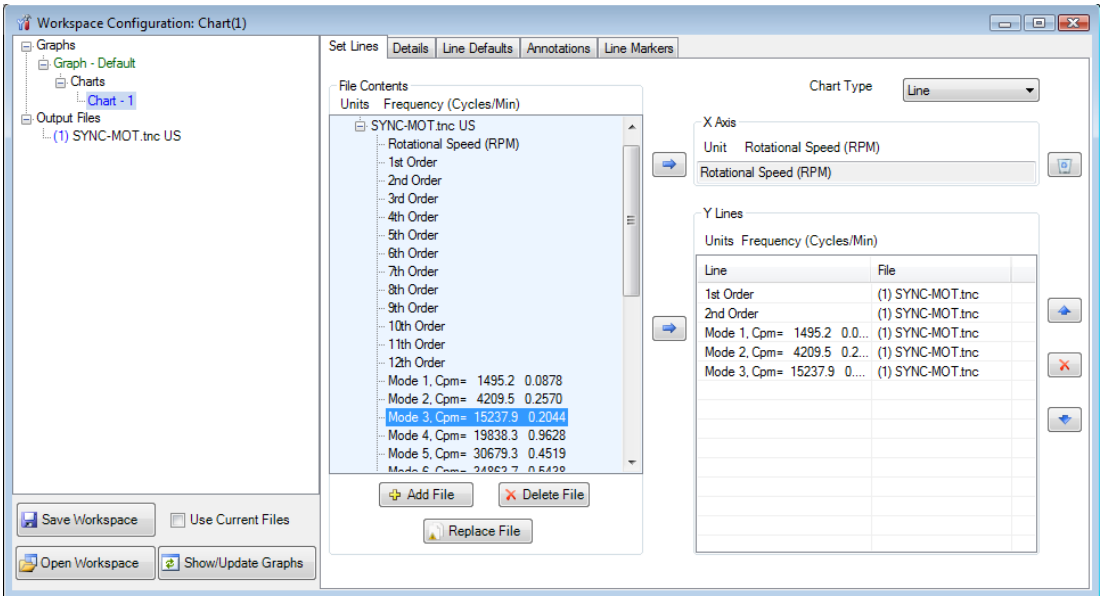
For long drive trains, visualization and animation of torsional behavior, the angular twists displayed have a maximum range of +/- 90 degrees and the twist lines extend out beyond the model surface by a factor of 2 times the shaft's maximum OD as shown here.



3-Dimensional Presentations
Torsional Twist Mode

2-D Graphics Utility (ARMDGraph)

ARMDGraph is a 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 and 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 and graph settings.

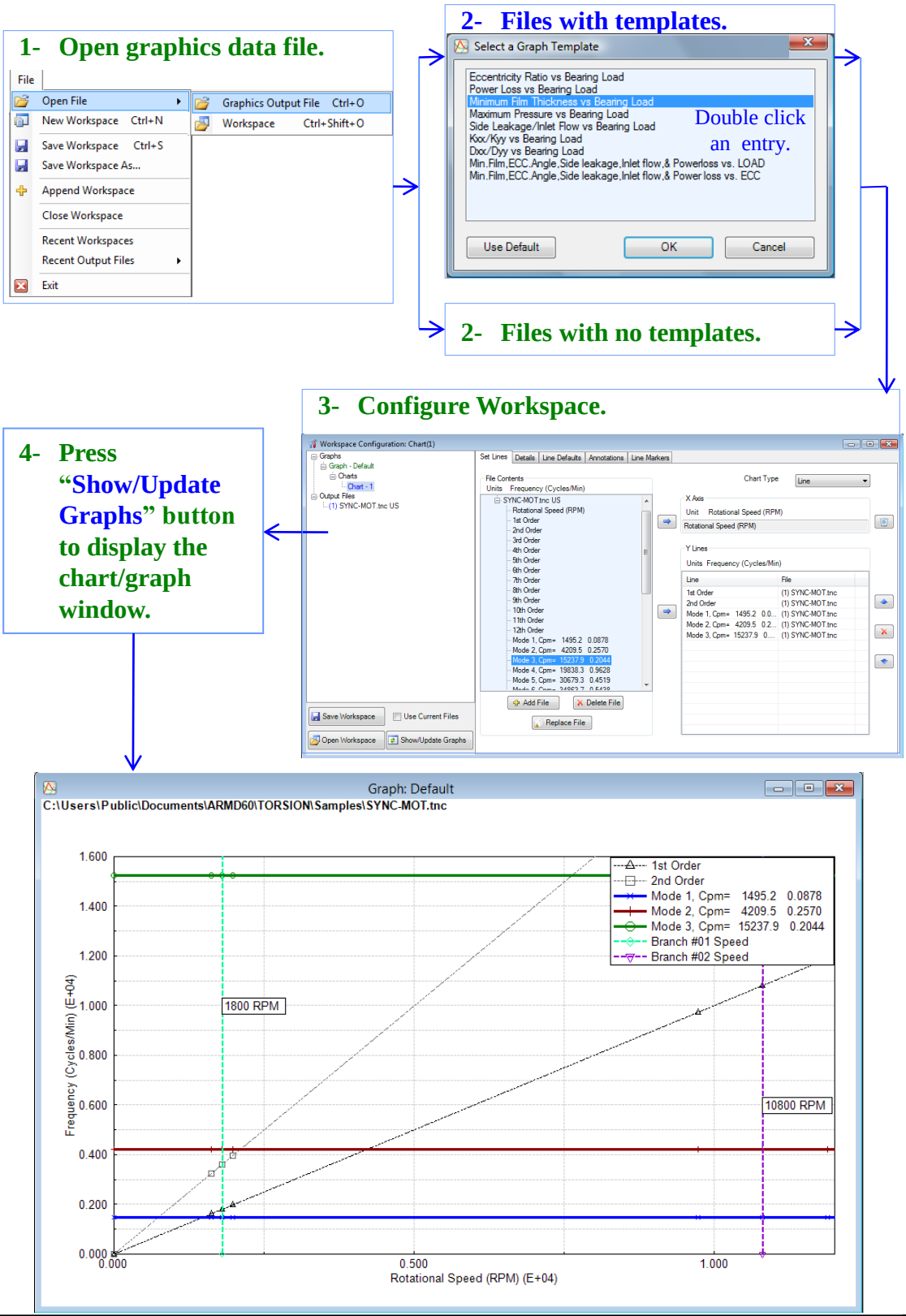


ARMDGraph features include:

- 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 and 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) including 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.

Graphics Utility **(ARMDGraph)**

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



Purchasing Options

ARMD is constructed from various solution modules. It can be tailored to suit your needs and budget. You may purchase any combination of programs/modules or all if you wish. Licensing is available as a single seat or multi-seat network configuration. With your purchase, the package includes the software (CD or download), quick start manual, electronic user's manual, technology transfer and training session (optional), updates, maintenance, and support.

System Requirements:

Personal computer with Microsoft Windows 8, 10, 11 or higher (32 or 64 bit).

Remember, with **RBTS**, you get more than just the programs, you get the company with more than 50 years of experience in the areas of tribology and machinery dynamics.

For further information, please contact us.

RBTS, Inc.

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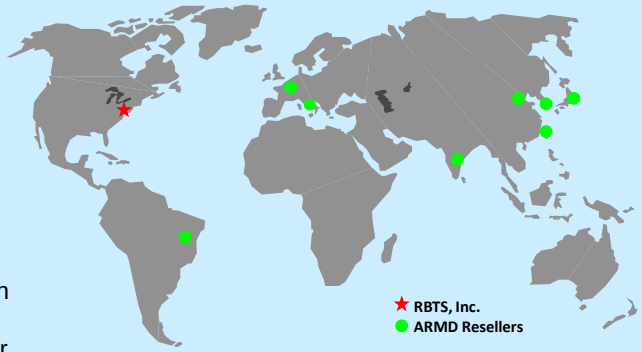
Phoenixville, PA 19460
USA

Telephone: **610-415-0412**
Facsimile: **610-415-0413**
Web: www.**rbts.com**
Email: **info@rbts.com**

ARMD™ - The Worldwide Leading Software For Rotating Machinery Analysis

***A**dvanced **R**otating **M**achinery **D**ynamics*

ARMD is a well established software package used worldwide to perform complete rotating machinery dynamic analysis. ARMD employs a user-friendly interface and window environment with pull-down menus and context-sensitive help. ARMD integrates the most advanced and complete rotor dynamics, torsional vibration, and bearing analysis programs under one environment in a seamless fashion to give you the power to model your rotating machinery with ease, efficiency, and above all accuracy. Some applications in which ARMD has been utilized include rotating machinery such as a miniature air turbine for a dental drill, a large turbine generator set for a power plant, a small compressor for an air conditioner, a pump for an artificial heart, a fuel pump for a jet engine, an electric motor and spindle for a miniature computer hard disk, a canned pump for petrochemical processing plant, synchronous motor driven drive-trains, and a gear box for an Uranium enrichment plant.



RBTS' software has gained international reputation for its:

- **Technical Capabilities**
- **Completeness**
- **User Friendliness**
- **Support & Service**

RBTS, *Inc.*

Rotor Bearing Technology & Software
1041 West Bridge Street
Phoenixville, PA 19460, USA

Please contact ***Dr. Andreas Laschet*** as RBTS' consultant and representation for the regions **Europe, Middle East, Africa** with the following communication details:

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Phone: +49 2204 84-2630 · E-mail: info@laschet.com · Web: **www.laschet.com**

YOUR PARTNER

for Europe & Middle East & Africa

Support for other countries on request.

- **Customer Engineering Support**
  (Rotor Dynamics & Torsional Vibrations)
- **ARMD Software Support**
- **Training Courses & Seminars**

Please contact: **Dr. Andreas Laschet**

Laschet Consulting GmbH

Friedrich-Ebert-Str. 75 · D-51429 Bergisch Gladbach · GERMANY

Ph: +49 2204 84-2630 · E-mail: info@laschet.com · **www.laschet.com**

ARMD™ – Advanced Rotating Machinery Dynamics – Software

BEARINGS Package

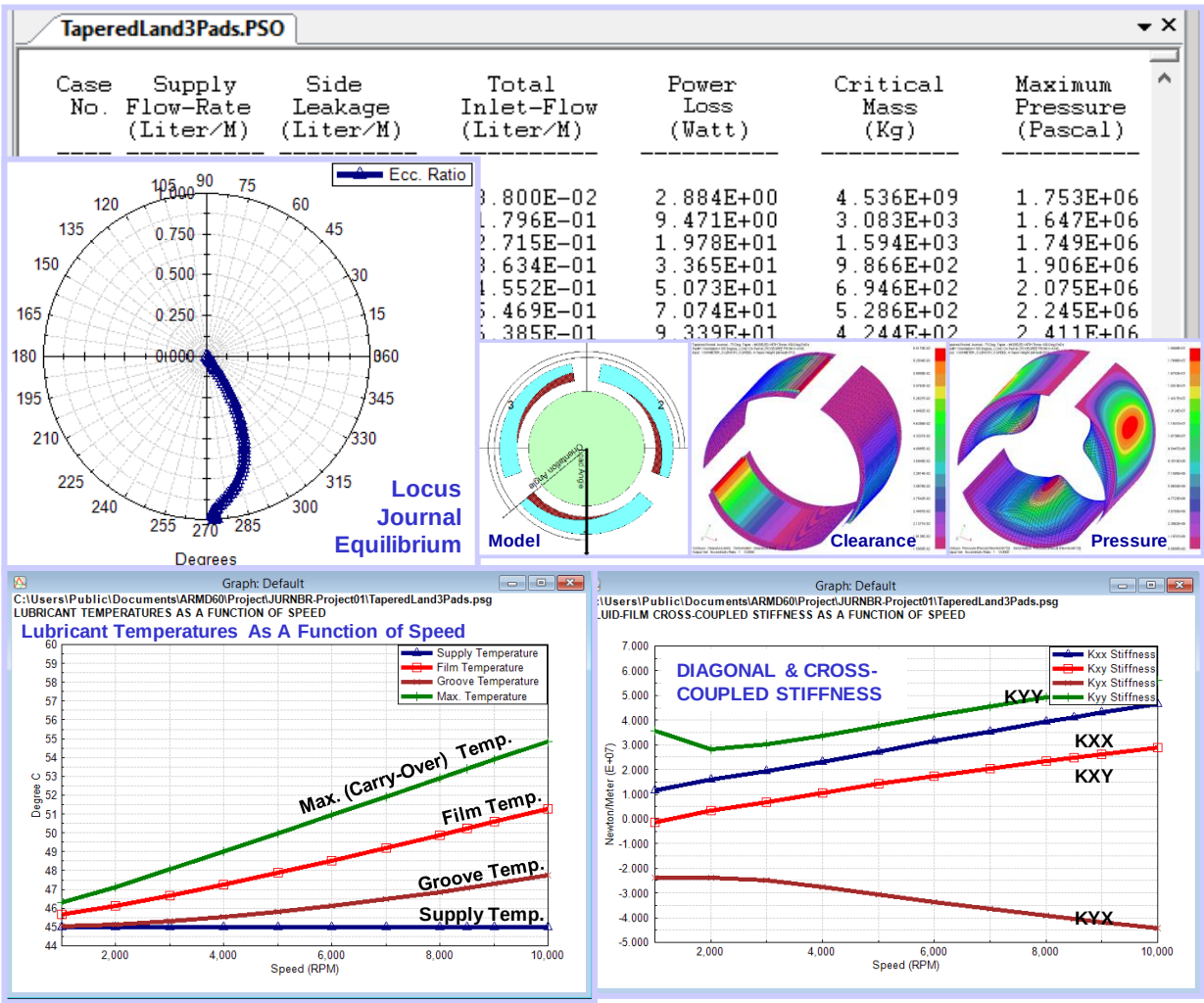
The **ARMD** software package is capable of facilitating comprehensive evaluations of fluid-film bearings. **Practically any bearing or bearing system available in the industry can be analyzed with one of the bearing solution modules**. The FLUID-FILM bearing modules (JURNBR, HYBCBR, THRSBR and TILTBR) solve the lubrication problem in two dimensions eliminating any approximation typically associated with one dimensional analysis or with look-up table methods.

- Journal
- Conical
- Thrust
- Tilting Pad

Complete performance predictions of hydrodynamic, hydrostatic, and hybrid lubricated journal, conical and thrust bearings operating in the laminar and/or turbulent regime can be generated. Simulation capabilities include effects such as cavitation, misalignment, pressurized boundaries, pressurized grooved feeding system, pressurized nozzle feeding system, surface/structural deviation, and lubricant feed circuitry (JURNBR, HYBCBR) with specified pressures or restrictors (capillary, orifice, or flow control valve), groove geometry and chamfers.

Results generated with the fluid-film bearing modules include:

- Load capacity / journal or runner position
- Attitude angle
- Viscous power loss
- Righting moments
- Flow requirements
- Stability (bearing whirl)
- Spring and damping coefficients
- Clearance and pressure distribution
- Recess pressures and flows
- Heat balance and temperature rises for bearing system and individual pads



ARMD™ Software – BEARINGS Package

Journal & Thrust Bearings
Fixed/Tilting Pad Geometries

- **Bearing Solver**
- **Post-Processor Single Case**
- **Post-Processor Multiple Case**

The release of RBTS' ARMD Version 6 fluid-film bearing modules is a major milestone in the product's development history, rolling out a **completely new and improved** graphical user interface for the package with enhanced numerical capabilities and new technical features. The software's front end was redesigned with our customers' and industry's input to incorporate the most logical, efficient, and productive techniques to model and analyze common as well as complex configuration, fluid-film lubricated journal and thrust bearings, of all sizes with ease.

ARMD users will immediately see the improvements as bearing design data are presented in a flatter, more accessible format, with key fields and analysis options readily visible from the main data entry screens. Fluid-film bearing design and performance evaluation productivity is vastly improved as a wide selection of templates accompanied by a "wizard" style sequence of dialogs allows the user to setup and evaluate most of the commonly used bearings in industry with few key strokes. Tab selected grids and input forms allow the user to see all of the data on screen at the same time. Furthermore, the ability to simultaneously run multiple instances of the program permits rapid side-by-side comparison of results.

Bearing configurations and special features that can be evaluated with the various solution modules include but not limited to:

Fixed Geometry Cylindrical and Conical Journal Bearings (JURNR & HYBCBR)

- Plain surface
- Multi-groove
- Pressure dam
- Elliptical or lemon
- Rayleigh step or pocket
- Tapered land
- Lobe or canted lobe
- Any configurable pad surfaces
- Multi-recess

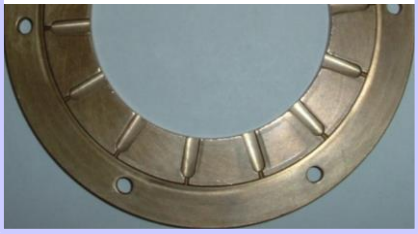
Tilting-Pad Journal Bearings (TILTBR)

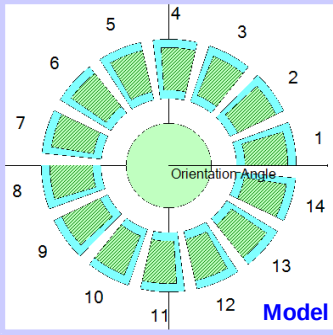
- Central pivot
- Offset pivot
- Evenly spaced pads
- Grouped pads
- Load between pads
- Load on pad
- Any load direction
- Any preload
- Leading/trailing edges taper
- Fluid-inertia force effects
- Support pivot stiffness

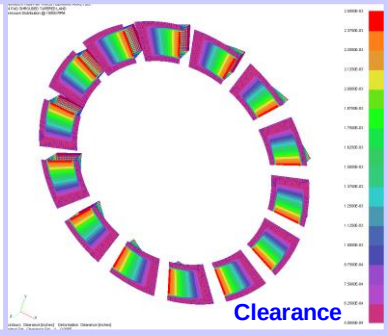
Fixed and Tilting-Pad Geometry Thrust Bearings (THRSBR)

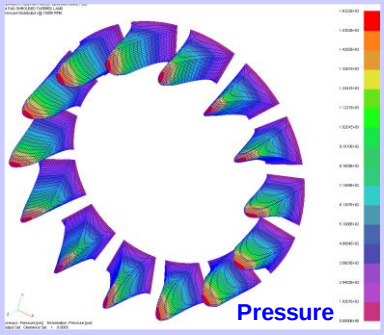
- Plain surface
- Multi-groove
- Step land
- Step pocket
- Tapered land
- Taper pocket
- Tilting pad
- Compound taper
- Any configurable pad surfaces

Sample Gearbox Thrust Bearing
14 pad shrouded tapered land configuration operating at 15KRPM

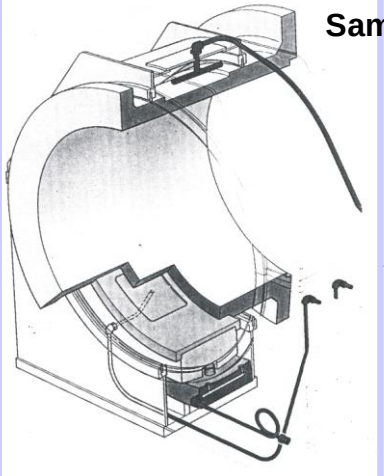


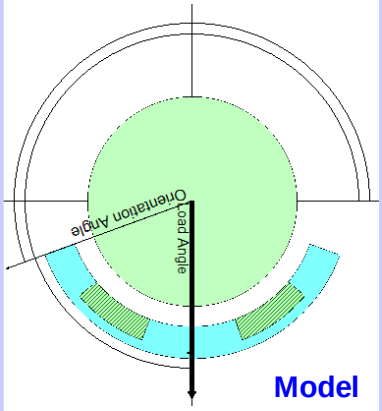


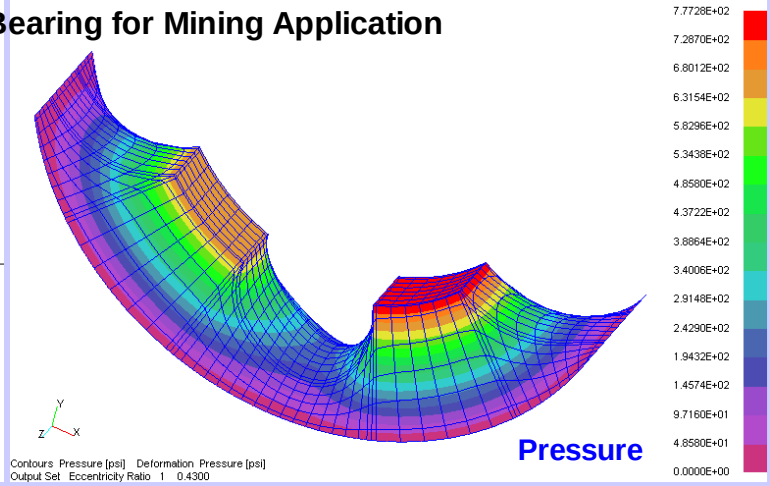




Sample Hydrostatic/Hybrid Bearing for Mining Application







ARMD™ Software – BEARINGS Package

Illustrated below, complete bearing performance results are generated when the Run button is pressed. The solution is performed for user specified operating conditions taking into consideration the pressurized feeding system. Heat balance is performed for the overall bearing system as well as individual pads in the bearing.

Modeled Bearing Details

Scroll through cases.

Complete Bearing Performance Results including bearing system and individual pad heat balance.

Pressure/ Clearance Distributions 3D View Button

Run Analysis

Generated text output after Run button is pressed

Post-Processor

Description

Sample Problem 6 - 5 Pad Tilting Pad Journal Bearing.
High Speed Test Rig Support Bearings.
Pad Pivot Stiffness NOT Included.

Diameter	3.5	Pad Angle	60.0	# of Pivot Clearances	50
Axial Length	2.5	Orientation Angle	0.0	Viscosity	1.000000e-06
Radial Clearance	0.004	Rotational Speed	20000.0	Full Matrix	☐

Single Case | Multiple Cases | Lubricant Properties

1 of 20 | Lube/Chamfer | Run | 3D

Operating Conditions

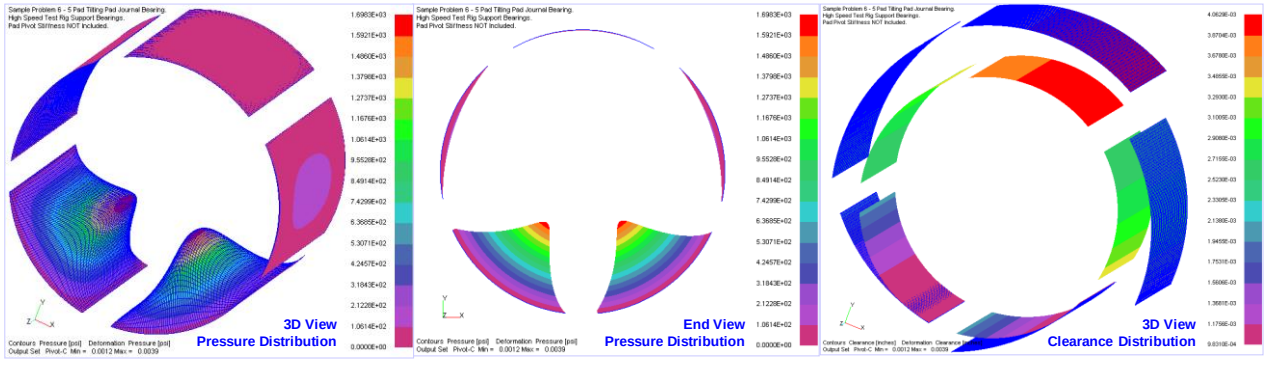
Clearance	0.004	Load	5000.0	Load Angle	270.0	Ort. Angle	90.0
Preload	0.4	Speed	20000.0	Grv. Angle	0.0	No. of Pads	5.0

```
Min.Film Thick.->   9.8316E-04 (Inch)|  ECC = 0.6344 @ Angle = 270.00 (Deg)
Power-Loss   --->   2.5591E+01 (HP)   |  Side-Leakage QF ->  1.7102E+00(Gpm)
Load Capacity -->   4.9955E+03 (Lbf)  |  Inlet-Flow   QI -> -1.5409E+01(Gpm)
|-------------------------------------|-------------------------------------|
Supply-Oil Temp.>  119.997   (Deg.F) |>>>   STIFFNESS (Lbf/Inch)
Supply Flow Rate>    6.1604  (Gpm)   |  KXX ; KXY -->  3.883E+06  1.229E+00
Film-Temp (avg.)>  176.056   (Deg.F) |  KYX ; KYY -->  1.690E+00  6.829E+06
Viscosity ------>  1.017E-06 (Rens)  |-------------------------------------|
Heat Content --->    3.622  (BTU/G/F)|>>>   DAMPING (Lbf-Sec/Inch)
Groove Temp. --->  165.765   (Deg.F) |  DXX ; DXY -->  1.637E+03  3.463E-04
Max. Temp.(avg.)>  186.347   (Deg.F) |  DYX ; DYY -->  1.420E-04  2.551E+03
|----Individual Pad Results Below-----|-------------------------------------|
Surface Velocity=  1.833E+04 (Ft/min)|  Projected Pressure=  5.709E+02 (PSI)
```

```
Individual Pad Heat Balance Results Estimate For NON-Flooded Environment
 Supply Flow Rate to Bearing = 6.1604E+00 (gpm) @ Ts = 1.2000E+02 (deg.F)
 Resulting in a Computed Mixed-Oil Exit Temperature -> 1.7064E+02 (deg.F)
 ------------------------------------------------------------------------

   Sump/Groove  Avg-Film     Max-Film     Min-Film      Power       Side
Pad Temperature Temperature  Temperature  Thickness     Loss        Leakage
No. (degree F.) (degree F.)  (degree F.)    (inch)      (hp)        (gpm)
--- ----------- -----------  ----------- ----------- ----------- -----------
 1   1.7247E+02  1.7550E+02   1.7853E+02  3.8107E-03  2.4191E+00  1.1370E-01
 2   1.6620E+02  1.7180E+02   1.7740E+02  2.5828E-03  3.3132E+00  3.9459E-01
 3   1.6167E+02  1.9445E+02   2.2723E+02  9.8316E-04  8.2725E+00  4.0366E-01
 4   1.7454E+02  2.0731E+02   2.4009E+02  9.8316E-04  8.2725E+00  4.0366E-01
 5   1.8108E+02  1.8668E+02   1.9228E+02  2.5828E-03  3.3132E+00  3.9459E-01
```

Ok | Cancel | Help



Purchasing Options

ARMD is constructed from various solution modules for rotating machinery/systems:

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

Tailored to suit your needs and budget. You may purchase any combination of programs/modules or all if you wish. Licensing is available as a single seat or multi-seat network configuration. With your purchase, the package includes software (CD or download), quick start manual, electronic user's manual, technology transfer and training session (optional), updates, maintenance, and support.

System Requirements

Computer with Microsoft Windows 8, 10, 11 or higher (32 or 64 bit).

Remember, with **RBTS**, you get more than just the programs, you get the company with more than 50 years of experience in the areas of tribology and machinery dynamics.

For further information, please contact us.

RBTS, Inc.

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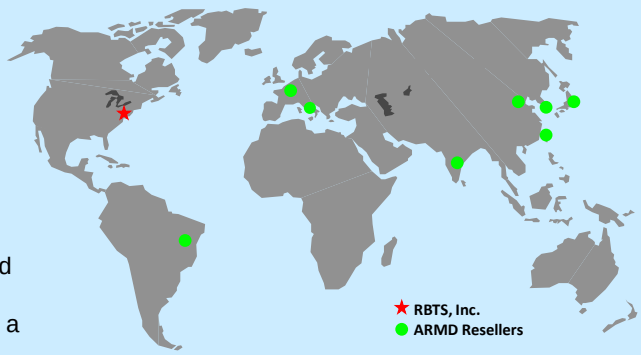
ARMD™ - The Worldwide Leading Software For Rotating Machinery Analysis

Advanced Rotating Machinery Dynamics

ARMD is a well established software package used worldwide to perform complete rotating machinery dynamic analysis. ARMD employs a user-friendly interface and window environment and context-sensitive help. ARMD integrates the most advanced and complete rotor dynamics, torsional vibration, and bearing analysis programs under one environment in a seamless fashion to give you the power to model your rotating machinery with ease, efficiency, and above all accuracy. Some applications in which ARMD has been utilized include rotating machinery such as a miniature air turbine for a dental drill, a large turbine generator set for a power plant, a small compressor for an air conditioner, a pump for an artificial heart, a fuel pump for a jet engine, an electric motor and spindle for a miniature computer hard disk, a canned pump for petrochemical processing plant, synchronous motor driven drive-trains, and gear boxes for a uranium enrichment plant and ship propulsion drives to name a few.



RBTS' software has gained international reputation for its:

- **Technical Capabilities**
- **Completeness**
- **User Friendliness**
- **Support & Service**

RBTS, Inc.
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for Europe & Middle East & Africa

Support for other countries on request.

- **Customer Engineering Support**
  (Rotor Dynamics & Torsional Vibrations)
- **ARMD Software Support**
- **Training Courses & Seminars**

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