

Advanced
Rotating
Machinery
Dynamics

TILTBR

Version 6.1

**New
Release**



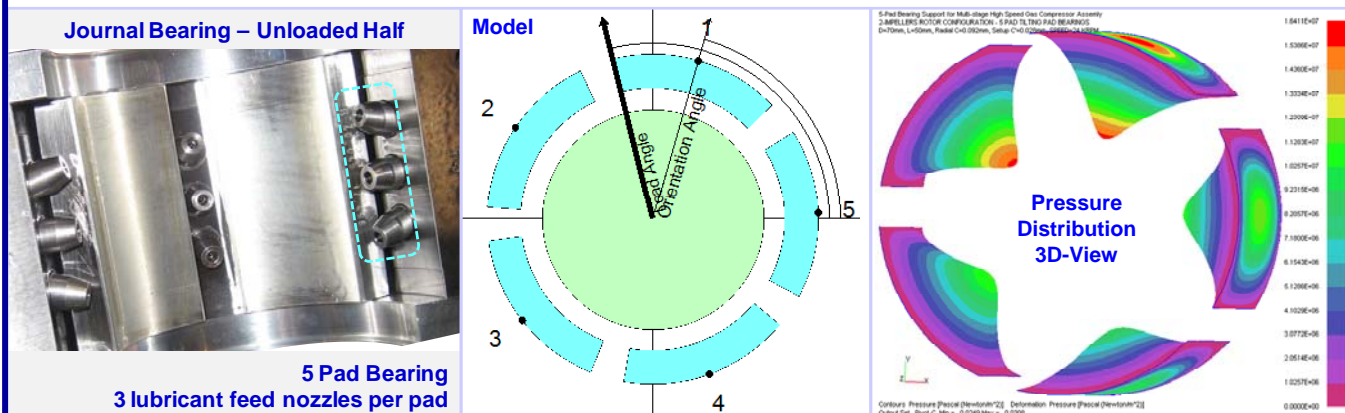
**Tilting-Pad
Geometry
Journal Bearings
(TILTBR)**

**TILTBR
Solvers**

**Post-Processor
Single Case**

**Post-Processor
Multiple
Case**

Tilting-Pad Geometry – Cylindrical Fluid-Film Lubricated Journal Bearings



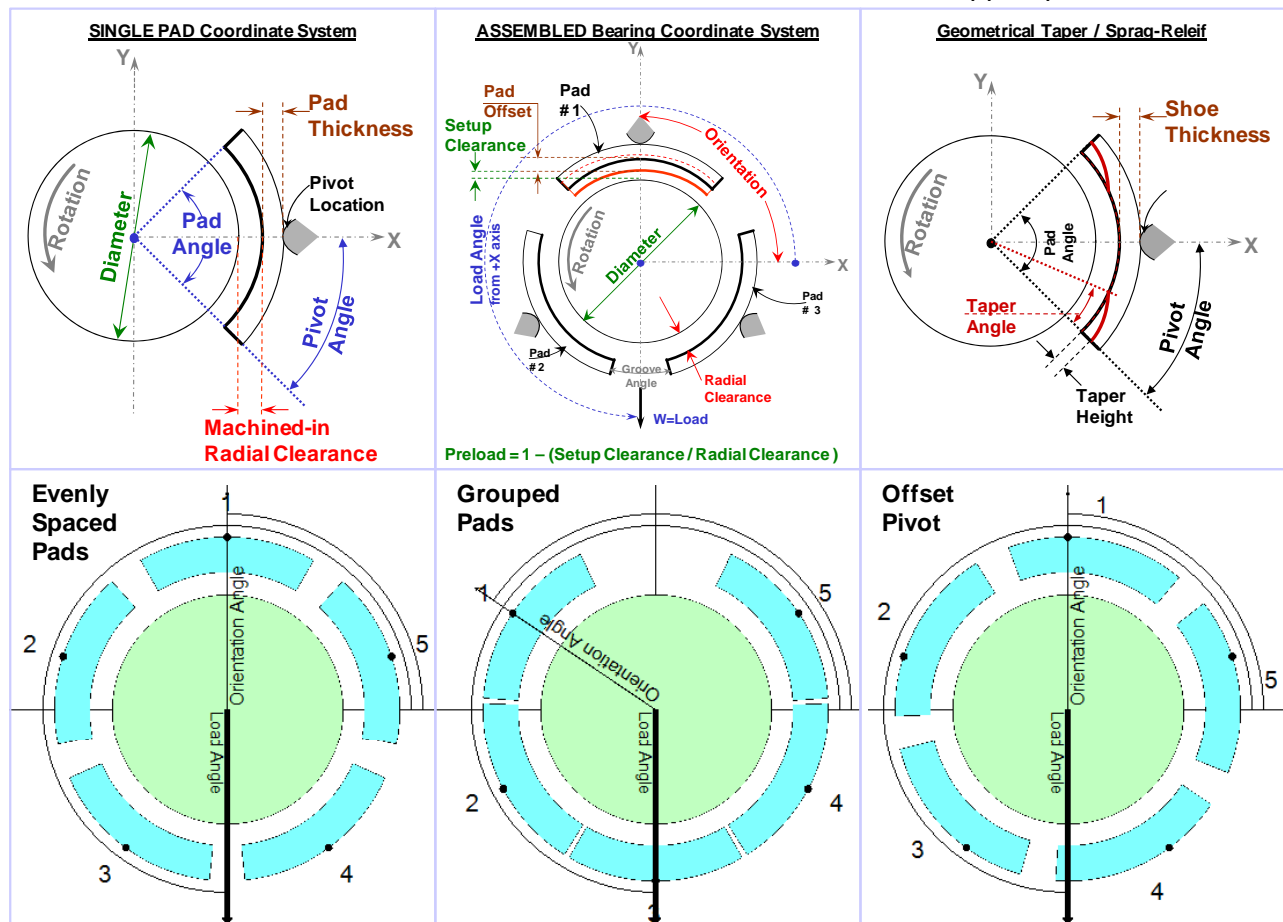
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The fluid-film bearing module **TILTBR** provides a full-scale computerized analysis that incorporates state-of-the-art numerical and modeling features. It is an advanced program designed to handle complex bearing geometries of tilting pad configuration. Complete performance predictions of **hydrodynamic**, **hydrostatic**, and **hybrid** lubricated tilting-pad journal bearings operating in the laminar and/or turbulent regimes can be generated. Analysis starts with subdividing the pad surface area into a grid pattern in two dimensions (circumferential & axial) and establishing the lubrication system of equations. Boundary conditions (pressurized boundaries, pockets, lines and holes with specified pressures) are incorporated to the system of equations. Geometrical tapered configurations at pad leading/trailing edges (sprag-relief) can be incorporated, as well as, considerations to fluid inertia effects on pad tilt, at pad leading edge. An advanced variable-grid finite-difference numerical method is employed for obtaining a solution, thus eliminating any approximation typically associated with one dimensional analysis or look-up table methods.

A wide variety of tilting pad geometry journal bearings can be analyzed including:

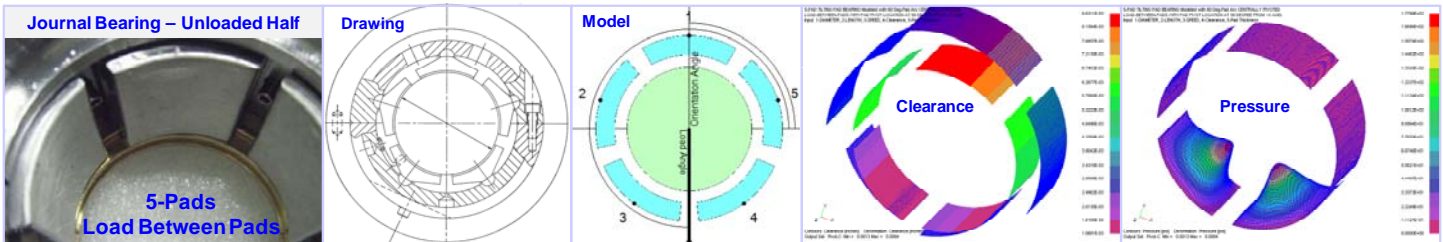
- Any number of pads
- Central pivot
- Offset pivot
- Evenly spaced pads
- Grouped pads
- Load between Pads
- Load on pad
- Any load direction
- Leading/trailing edges taper / sprag-relief
- Fluid-inertia force effects on pad tilt
- Support pivot stiffness



ARMD™ V6.1 – TILTBR Module

Simulation capabilities with **TILTBR** include such effects as lubricant feed circuitry with specified pressures and feed orifices/nozzles, pressurized boundaries or grooves, speed, load, clearance, preload, etc. Performance results include the following.

- Load capacity / journal position
- Attitude angle
- Viscous power loss
- Flow requirements
- Stiffness and damping (dynamic) coefficients including pad pitch degrees of freedom
- Clearance and pressure distribution
- Heat balance and temperature rises



TILTBR-6.TPO				
Case Number	Preload Ratio	Rotational Speed (Rpm)	Viscosity LBF-SEC/IN ²	Heat BTU/G
1	0.400	2.000E+04	0.000E+00	0.0
2	0.400	1.900E+04	0.000E+00	0.0
3	0.400	1.800E+04	0.000E+00	0.0
4	0.400	1.700E+04	0.000E+00	0.0
5	0.400	1.600E+04	0.000E+00	0.0
TILTBR-6.TPO				
Case Number	ECC Ratio	Minimum-Film Thick. (Inch)	Load (Lbf) Capacity	Ang Eccen
1	0.634	9.8316E-04	4.9955E+03	2.7
2	0.637	9.7755E-04	5.0008E+03	2.7
3	0.641	9.7195E-04	4.9982E+03	2.7
4	0.645	9.6494E-04	5.0019E+03	2.7
5	0.648	9.5793E-04	4.9952E+03	2.7
6	0.654	9.4861E-04	4.9985E+03	2.7
7	0.659	9.3893E-04	5.0019E+03	2.7
8	0.666	9.2707E-04	4.9954E+03	2.7
9	0.684	8.9340E-04	5.0029E+03	2.7
10	0.694	8.7657E-04	5.0015E+03	2.7
TILTBR-6.TPO				
Case Number	Supply-Oil Temp. (Deg. F)	Lub. Film Temp. (Deg. F)	Film-Viscos. LBF-SEC/IN ²	
1	1.2000E+02	1.7606E+02	1.0175E-06	
2	1.1999E+02	1.7340E+02	1.0582E-06	
3	1.2000E+02	1.7071E+02	1.1019E-06	
4	1.1999E+02	1.6799E+02	1.1486E-06	
5	1.1999E+02	1.6524E+02	1.1989E-06	
6	1.1999E+02	1.6247E+02	1.2525E-06	
7	1.2000E+02	1.5969E+02	1.3101E-06	
8	1.2000E+02	1.5686E+02	1.3724E-06	
9	1.1999E+02	1.5395E+02	1.4433E-06	
10	1.2000E+02	1.5092E+02	1.5149E-06	
11	1.2000E+02	1.4818E+02	1.5917E-06	
12	1.2000E+02	1.4531E+02	1.6748E-06	
13	1.2001E+02	1.4246E+02	1.7634E-06	
14	1.2001E+02	1.3959E+02	1.8593E-06	
15	1.2001E+02	1.3674E+02	1.9617E-06	
16	1.2000E+02	1.3388E+02	2.0725E-06	
17	1.2001E+02	1.3107E+02	2.1902E-06	
18	1.2001E+02	1.2824E+02	2.3174E-06	
19	1.2001E+02	1.2533E+02	2.4597E-06	
20	1.2001E+02	1.2533E+02	2.4597E-06	

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 1.00000E-06

Radial Clearance 0.004

Rotational Speed 20000.0

Full Matrix ☐

Single Case

Multiple Cases

Lubricant Properties

1 of 20

Lube/Chamber

Run

3D Viewer Button

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

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 (Reyn)

DAMPING (Lbf-Sec/Inch)

Heat Content -> 3.622 (BTU/G/F)

DXX ; DXY -> 1.637E+03 3.463E-04

Groove Temp. -> 165.765 (Deg. F)

DYX ; DYY -> 1.420E-04 2.551E+03

Max. Temp. (avg.) -> 186.347 (Deg. F)

Individual Pad Results Below

Surface Velocity = 1.833E+04 (Ft/min)

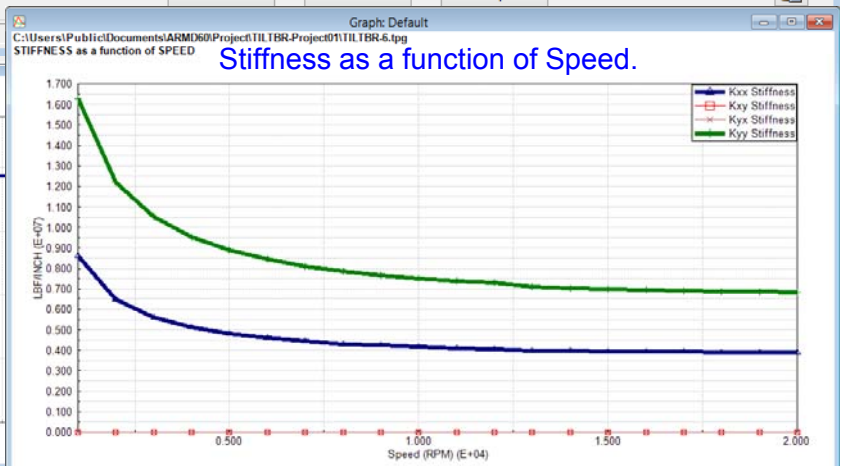
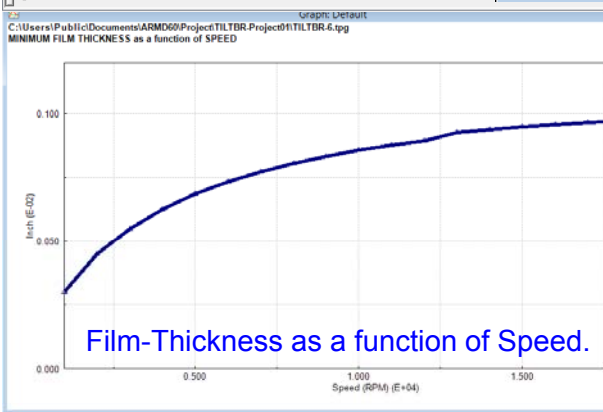
Projected Pressure = 5.709E+02 (PSI)

Ok

Cancel

Help

Generated text output after Run button is pressed



ARMD™ V6.1 – TILTBR Module

- *The release of RBTS' **ARMD Version 6.1 TILTBR** module 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. TILTBR 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 bearing configurations with ease.*

ARMD TILTBR 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.

A vastly improved pad configuration tab, on the basic bearing design input data form, allows the user to rapidly configure the pad and assembled bearing with complete freedom in pad and bearing attributes.

By identifying new trends from industry, along with RBTS' involvement in bearings design, performance evaluation and troubleshooting, new technical capabilities were added to the software including the ability to define pad pivot stiffness and pad leading/trailing edge tapers. User specified groove angle (angle between pads) allows the assembled bearing to have evenly spaced pads (typical industry design) or grouped pads.

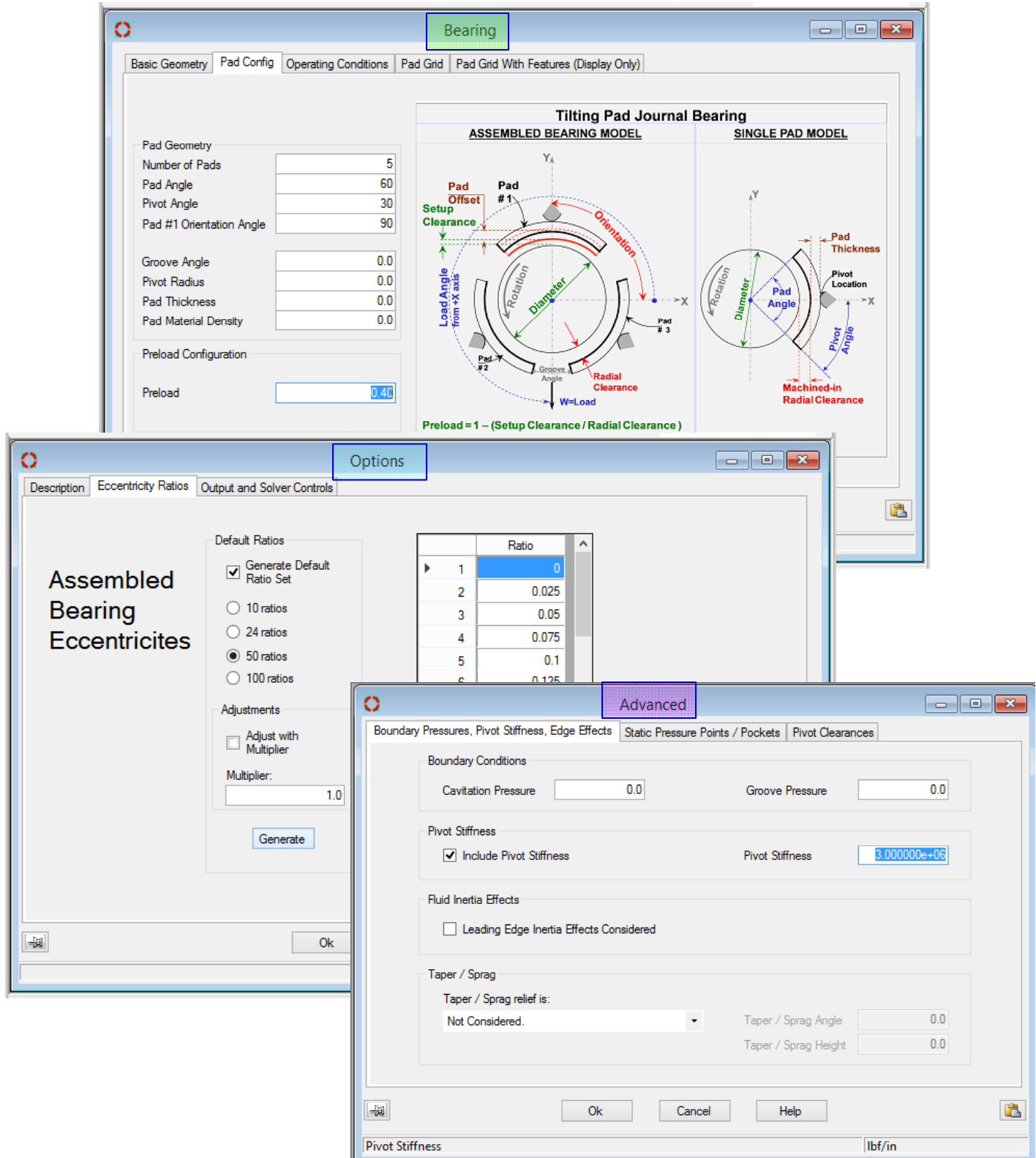
Version 6 TILTBR users need only pick an overall grid density or design, and the user interface built-in analytical routines will generate the required grid network for the overall design, automatically modified as needed to add additional grid points at feature locations. Previous versions required the user to carefully design the fluid-film grid network in order to place design feature locations (like tapers, specified pressure regions, etc.) at existing grid points.

The grid design form now allows the user to specify grid locations by their physical positions instead of their incremental distance from their neighboring grid points. If a grid point increment is changed resulting in a mismatch between the size of the grid and the size of the bearing, a single button click will proportionately resize the grid to fit the bearing.

ARMD™ V6.1 – TILTBR Module

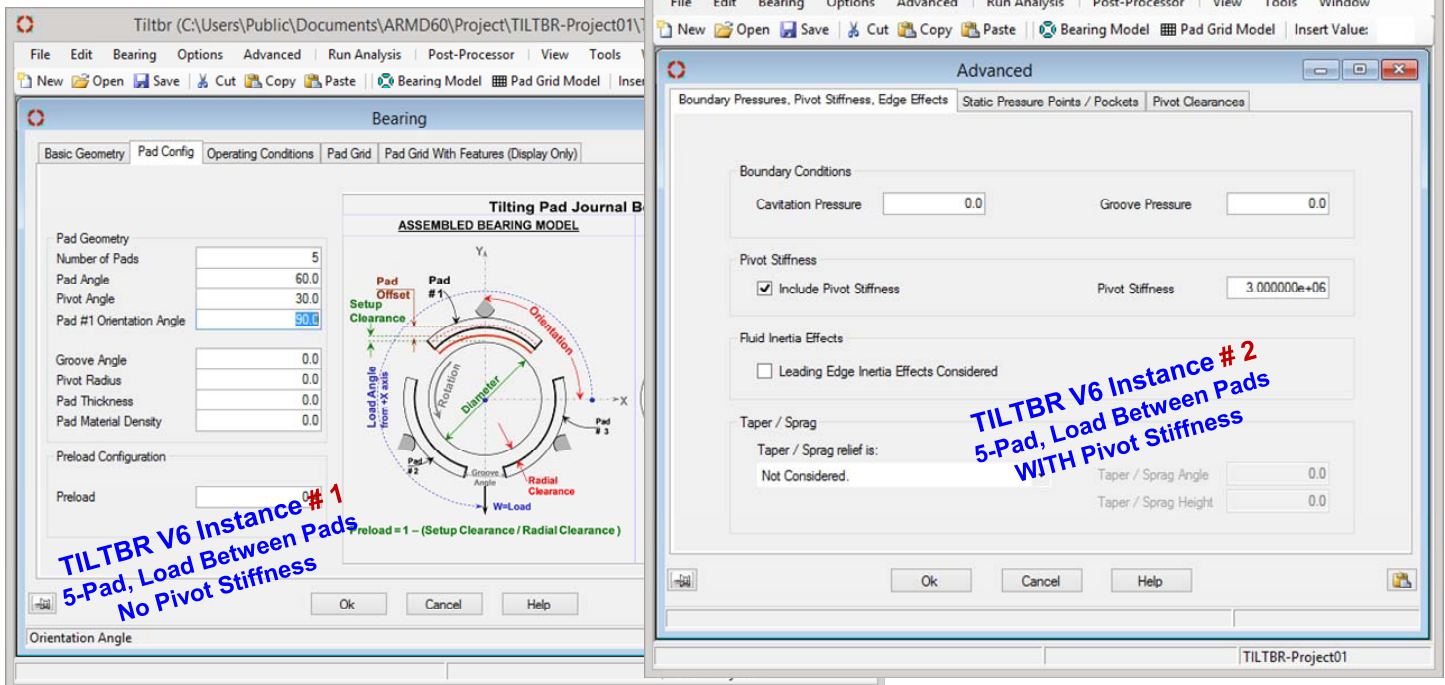
Enhanced Modeling, Usability and Technical Features Include:

- **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 or mouse right-click pop-up menu lists.

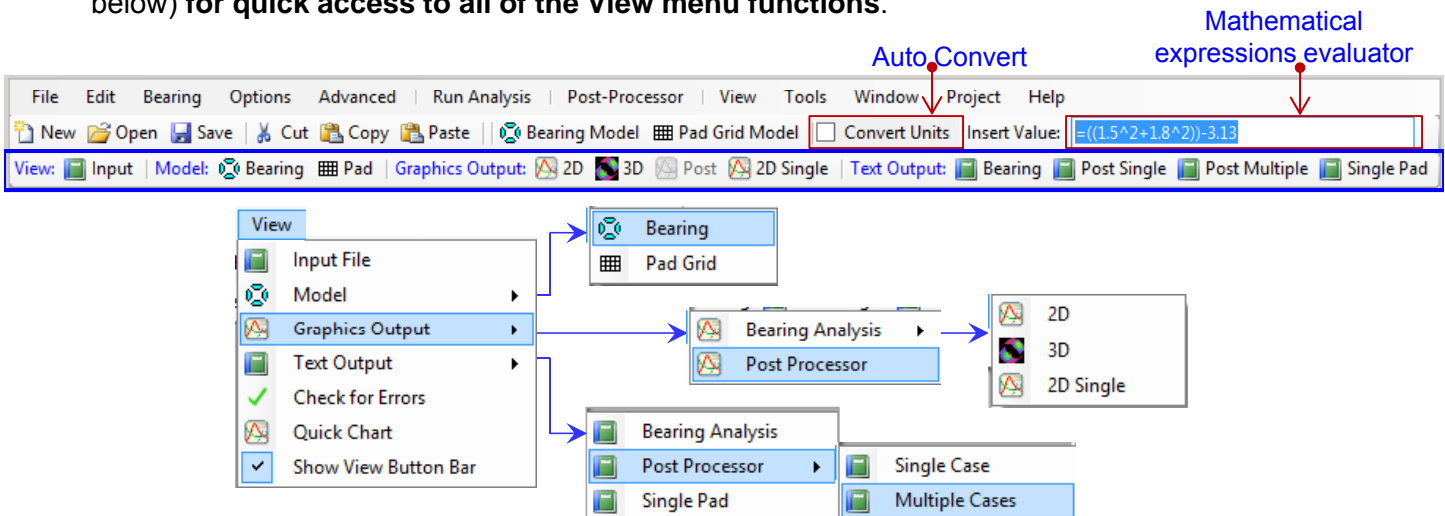


ARMD™ V6.1 – TILTBR Module

- **Multiple instances of TILTBR.** The newly developed package can now **open simultaneous multiple instances of TILTBR**, so side-by-side comparison of bearings model variations and analysis results are easy and efficient. This functionality permits multiple instances of TILTBR Version 6 or Version 5.8 to be accessible on your display, from which, portions of a model (grid layout, eccentricities, etc.) can easily be moved from one instance to another.



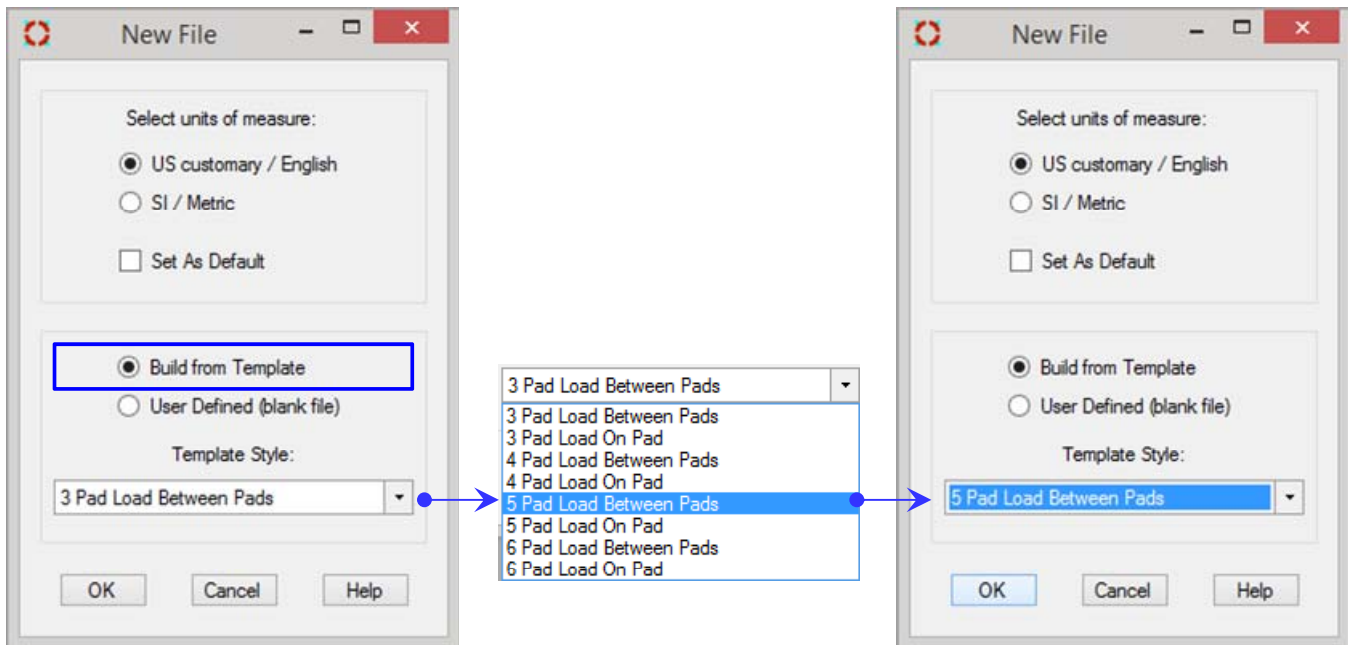
- **User Configurable Expanded Toolbar.** The main toolbar contains controls used to access frequently used functions (these functions are usually accessible from a menu as well). When a function is not available, its control on the toolbar will be disabled and displayed in a faded gray color. A user configurable **expanded Toolbar** has been added (second row of the toolbar shown below) for quick access to all of the **View menu functions**.



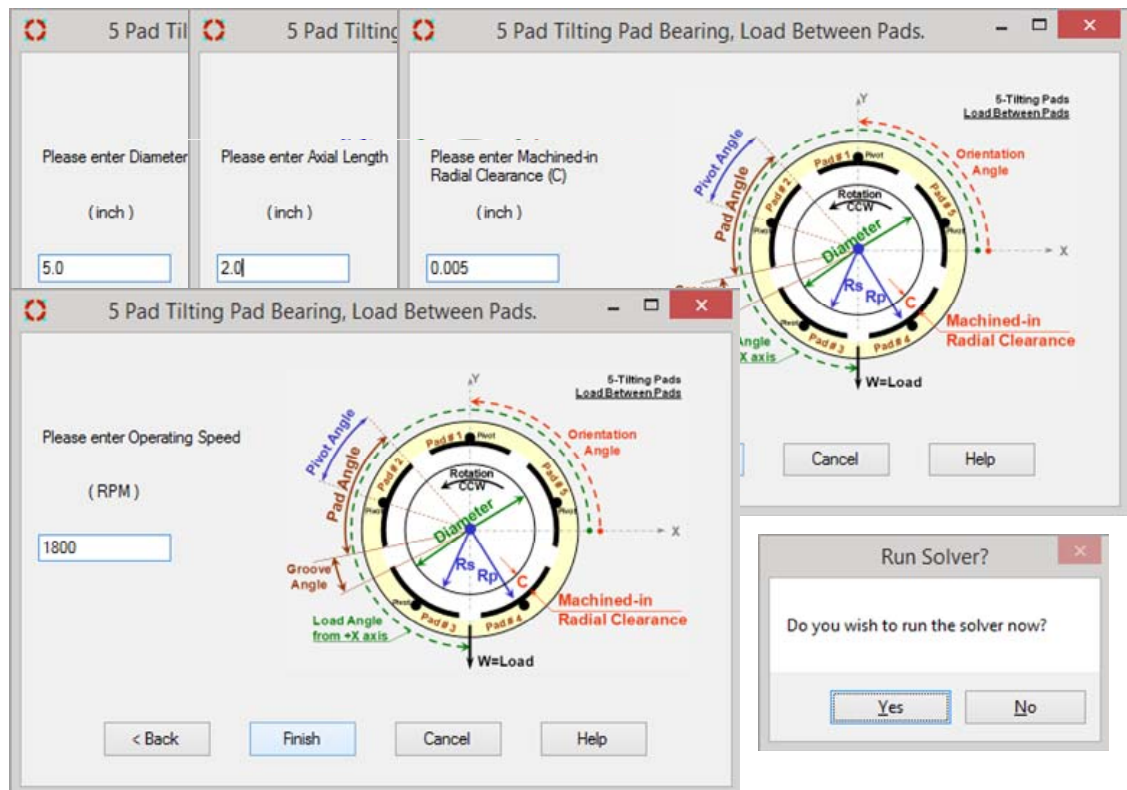
ARMD™ V6.1 – TILTBR Module

Many of the improvements incorporated into ARMD TILTBR Version 6.1 are specifically directed towards simplicity, increasing usability and productivity as illustrated below:

- **Pre-Configured Bearings and Orientations.** The newly developed package incorporates a significant number of preconfigured bearing types (templates) used in industry. When creating a new bearing model the built-in wizard and templates expedite the creation of bearing models and provide bearing performance results in few keystrokes. Users can create additional templates of their specific bearing configurations and utilize them during their normal work flow.

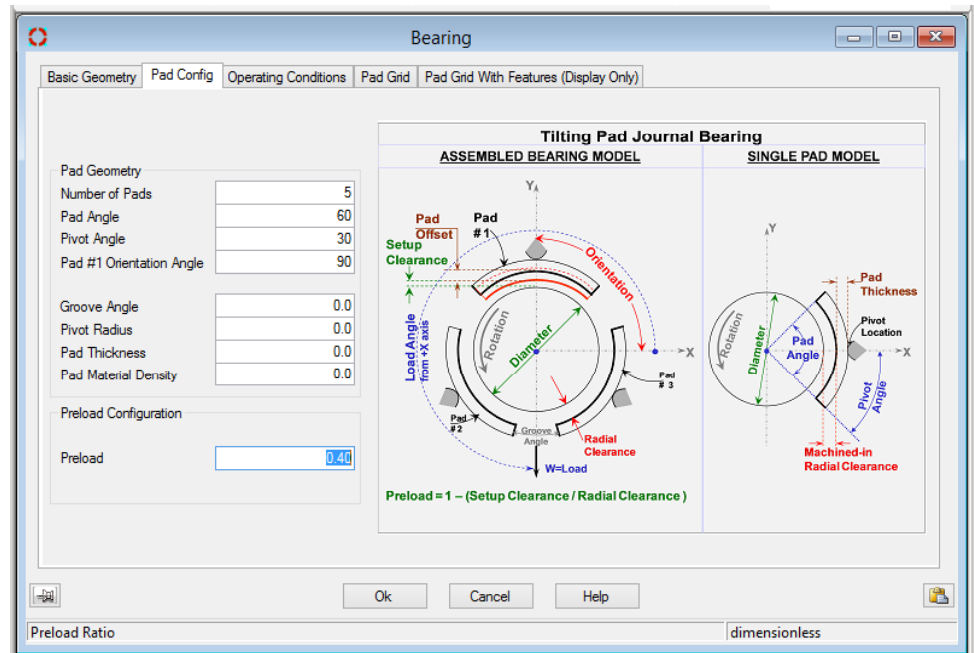


As an example it takes only five steps utilizing templates/wizard to model a bearing with its geometry and operating speed to provide a complete solution of bearing performance.



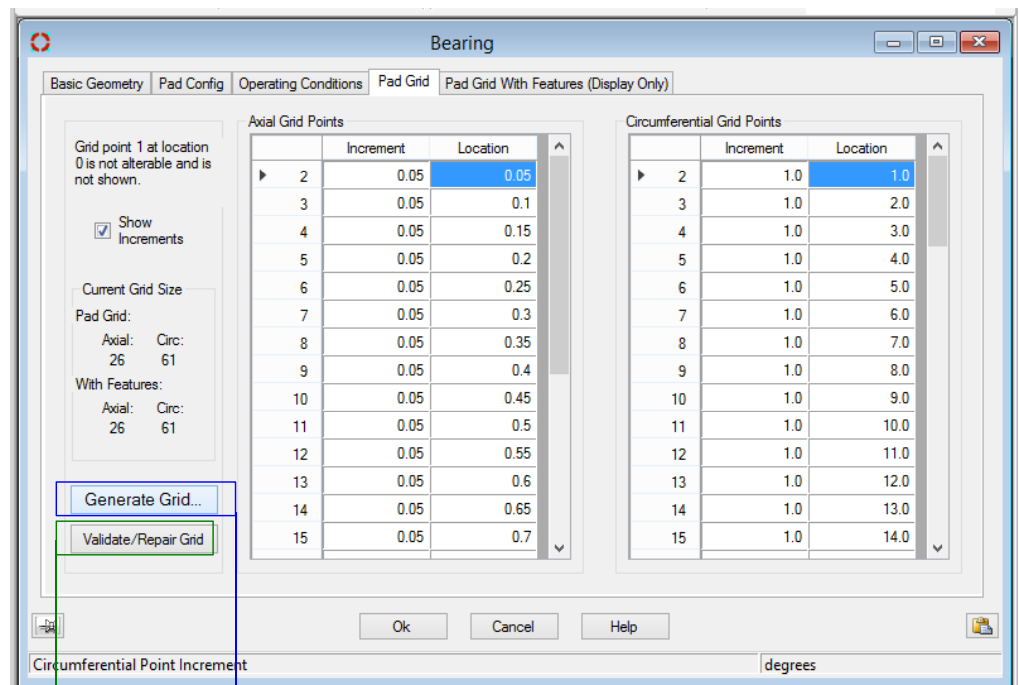
➤ Bearing Pad Configuration – Bearing Form.

A vastly improved pad configuration tab allows the user to specify basic bearing pad configuration and preload in one location as shown here.



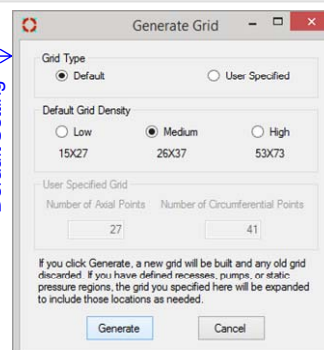
➤ Bearing Pad Grid – Bearing Form.

The pad grid network is utilized for formation and solution of the lubrication equations resulting in the overall bearing performance results. In previous versions of the software, the grid network was defined by the user. The new version, by default, automatically generates the grid network with user option of low, medium, or high density gridding. User Specified grid network can be selected to override the default setting. As illustrated here, the new version allows the user to specify grid locations by their physical positions instead of just their incremental distance from their neighboring grid points.

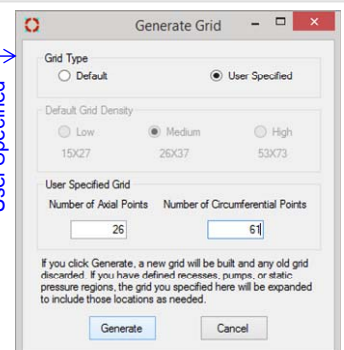


If a grid point increment is changed resulting in a mismatch between the size of the grid and the size of the bearing, a single button click will proportionately resize the grid to fit the bearing

Default Setting



User Specified



ARMD™ V6.1 – TILTBR Module

- **Eccentricity Ratios – Options Form.** Journal eccentricity in the bearing bore is defined as the ratio of journal position to bearing pad machined-in radial clearance. For an assembled bearing with no preload, the eccentricity ratio ranges from 0.0 (concentric) to just below 1.0 for eccentric operation assuming the journal is only moving in the direction of a pad pivot location.. Eccentricity ratios are automatically generated (10, 24, 50 default, 100 eccentricities, or as specified by the user) as shown below.

	Ratio
1	0
2	0.025
3	0.05
4	0.075
5	0.1
6	0.125
7	0.15
8	0.175
9	0.2
10	0.25
11	0.3
12	0.35
13	0.4
14	0.45

Journals in tilting pad bearings may operate above eccentricity ratio of 1.0 (operation between pads with pad tilt), and for heavily loaded bearings, the eccentricity ratio may reach as high as 2.0. The new version provides the user with means to exceed the maximum computed eccentricity ratio with the newly implemented "Adjustments" option.

In previous versions eccentricities above 1.0 had to be specified manually. In version 6 the adjustments option allows the user to extend the eccentricity ratio computation range by simply checking the "Adjust for Multiplier" box and entering a multiplier. The Generate button is then pressed to generate the desired range of eccentricity ratios.

Default Ratios

☒ Generate Default Ratio Set

☐ 10 ratios

☐ 24 ratios

☒ 50 ratios

☐ 100 ratios

Adjustments

☐ Adjust with Multiplier

Multiplier: 2.0

Generate

ARMD™ V6.1 – TILTBR Module

- **Output and Solver Controls – Options Form.** Version 6 provides the user with condensed, intermediate and detailed output results of the solution by simply selecting the appropriate radio button. Additionally the **restore default button** provides default settings on increments for stiffness and damping coefficients to be generated.

- **Static Pressure Points / Lines / Pockets – Advanced Form.** New features implemented in version 6 provide the user with means to specify pressure conditions, some of which include:

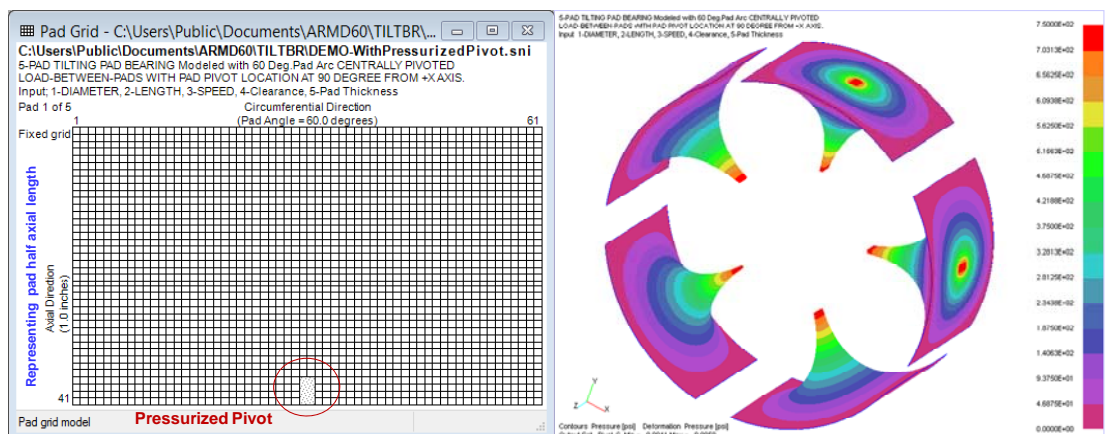
- Pressure point at an intersection of a radial and circumferential location in the pad surface area.
- Pressure line in either radial or circumferential direction in the pad surface area.
- Pressure pocket/box in the pad surface area.

Pressurized points, lines, or pockets are specified by their physical geometry (of axial and circumferential positions) in the bearing pad surface area, unlike previous versions which permitted only the specification of pressures at already established grid points.

	Axial1	Axial2	Circ1	Circ2	Pressure
1	0.9	1.0	29.0	31.0	750.0

The above specified conditions illustrate (shown below with the display of the pad grid layout) the specification of pressurized pocket/box bounded axially at 0.9 and 1.1 inches (due to

symmetry), and circumferentially at 29.0 and 31.0 degrees, representing a high-pressure recess feed at the pad pivot location.



ARMD™ V6.1 – TILTBR Module

- **Boundary Pressures, Pivot Stiffness, Fluid Edge Effects – Advanced Form.** New features implemented in version 6 provide the user with means to specify pad support pivot stiffness to be incorporated in the assembled bearing fluid-film stiffness matrix. Checking the “*Include Pivot Stiffness*” box is all that is needed. User may specify their own value of the pivot stiffness or the default value of 3.00E+06 (lbf/inch, or its equivalent in SI units) will be considered.

The screenshot shows the 'Advanced' dialog box with the following settings:

- Boundary Conditions:** Cavitation Pressure = 0.0, Groove Pressure = 0.0
- Pivot Stiffness:** ☒ Include Pivot Stiffness, Pivot Stiffness = 3.000000e+06
- Fluid Inertia Effects:** ☐ Leading Edge Inertia Effects Considered
- Taper / Sprag:** Taper / Sprag relief is: Not Considered., Taper / Sprag Angle = 0.0, Taper / Sprag Height = 0.0

Buttons: Ok, Cancel, Help. Status bar: Pivot Stiffness, lbf/in

Additionally, fluid inertia effects on pad tilt may be considered by simply checking the “*Leading Edge Inertia Effects*” box in the form.

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

Auto Convert

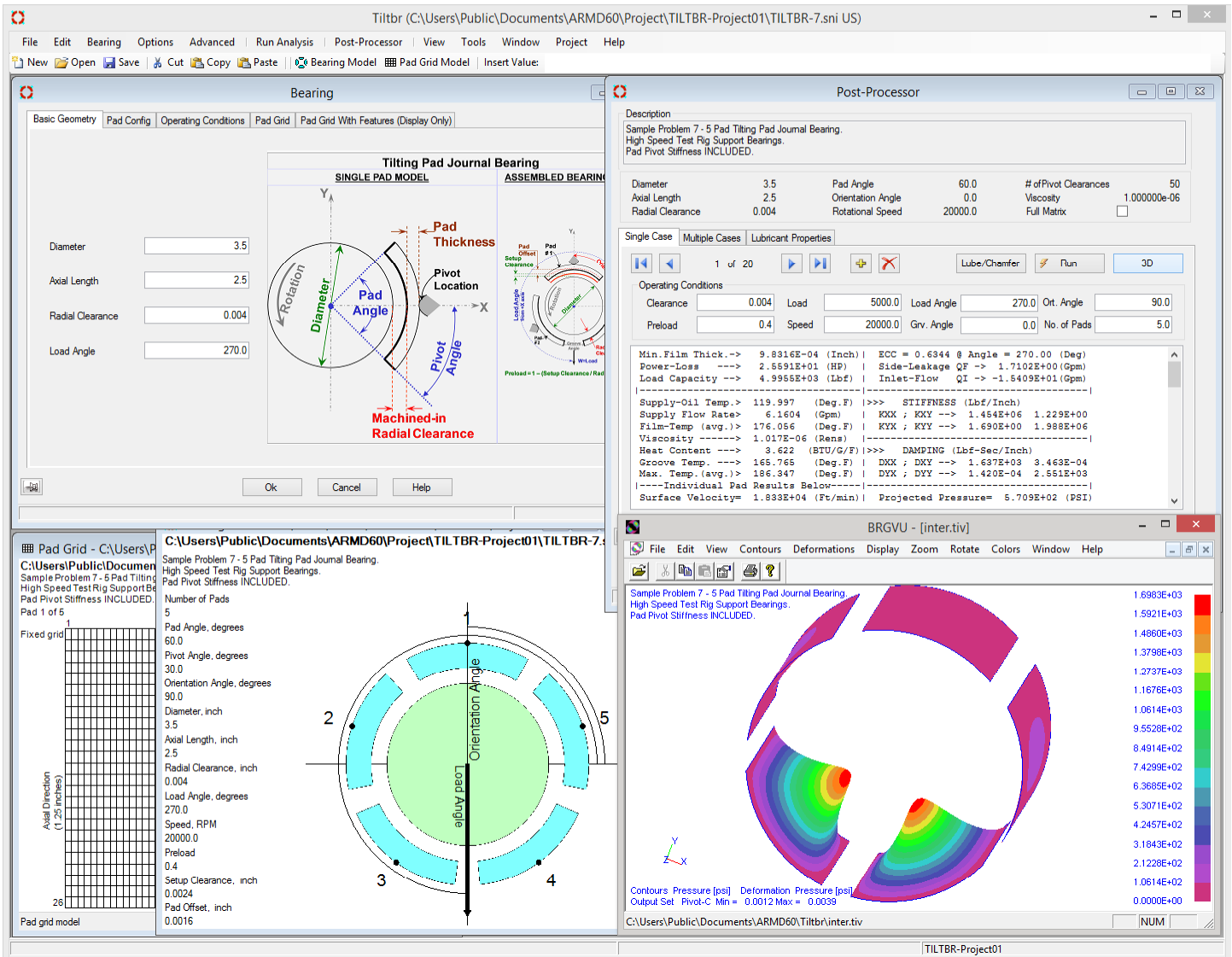
Mathematical Expressions evaluator

☒ Convert Units Insert Value:

- **Whole Number Display.** For improved legibility, defaulting to scientific notation when required. Trailing zeros are implied out to seven significant digits.
- **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.
- **Data 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.

ARMD™ V6.1 – TILTBR Module

- **Error diagnostics.** Quickly walks user through any model input errors. A mouse click navigates the user to the next error found.
- **Round Function.** Round function for data entry fields is accessible from the Tools menu, and can be declared for all data fields.
- **Data Entry.** All data entry forms can be open simultaneously for ease of model building & analysis.



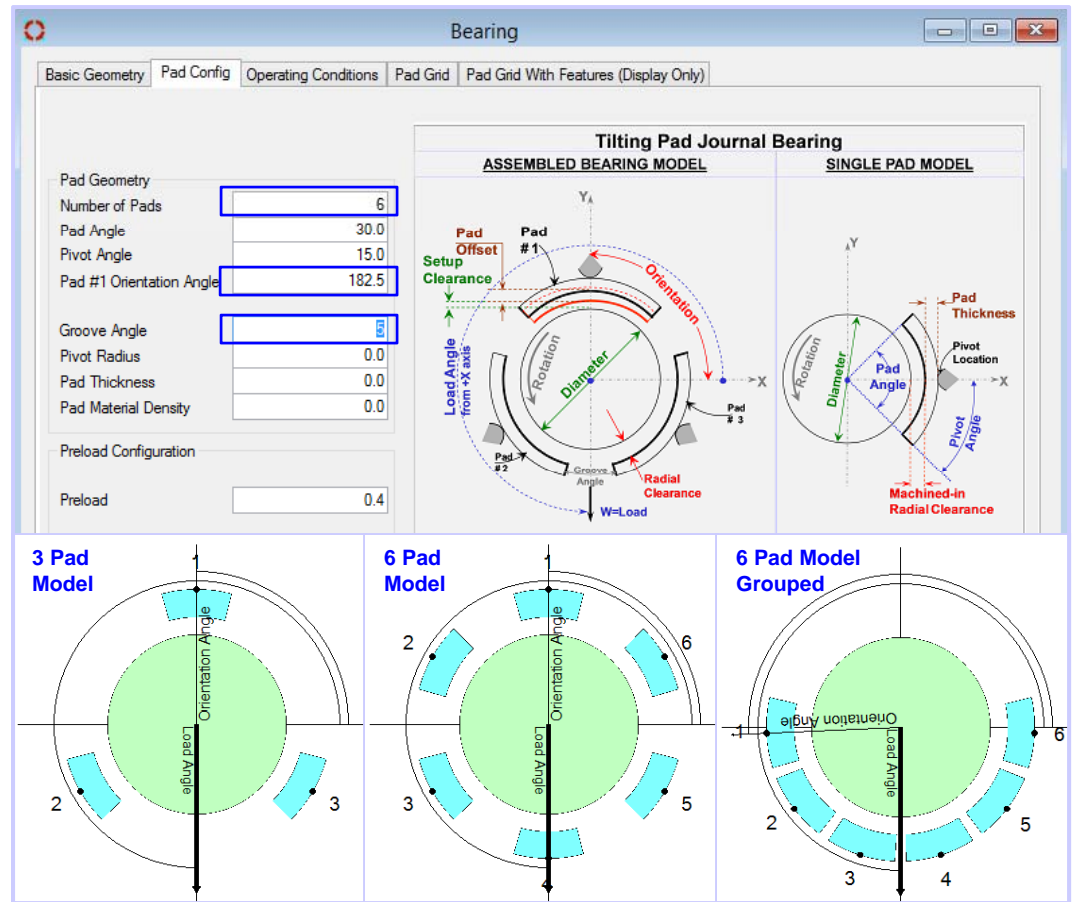
- **Data Entry Menus.** All data entry menus are visible at the Grid input page. Grids now feature selection check boxes and editing buttons where appropriate.
- **Quick Chart.** This feature rapidly displays an X-Y graph of entered tabular data for visual verification of correctness. ARMD Graph software is still available for complete graphic analysis capabilities.

ARMD™ V6.1 – TILTBRE Module

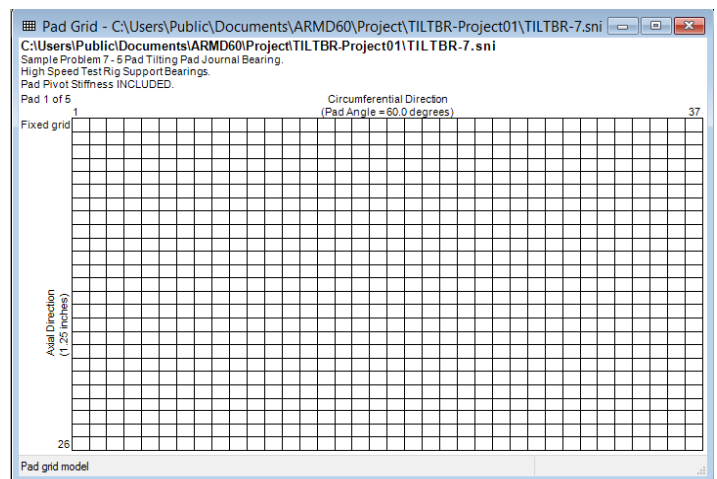
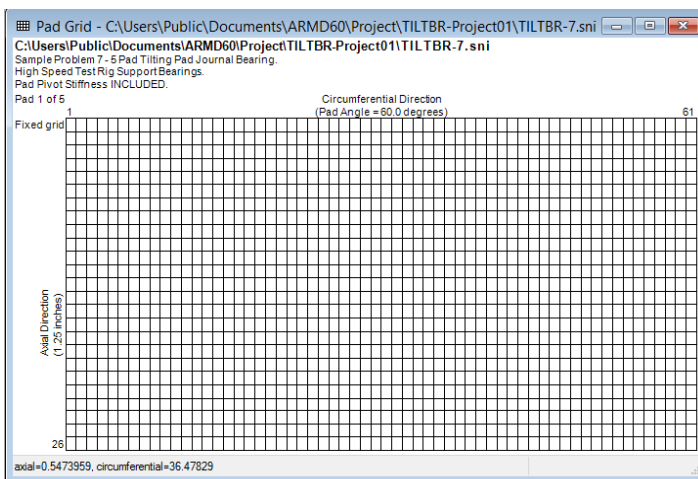
➤ Live 2-D Graphics Models.

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 the bearing model..

Changing the number of pads from 3 to 6, then grouping pads, will automatically modify the graphics model as shown here.



Modifying pad grid network size from 26 X 61 to 26 X 37 automatically update the pad grid as shown below.



➤ Metafile enabled copy and paste of bearing and pad grid graphics models for better reporting.

ARMD™ V6.1 – TILTBR Module

- **Post-Processor.** Following a complete bearing modeling and performance map solution as a function of pad pivot film-thickness/clearance, the post processor illustrated below immediately provides assembled bearing performance results when the Run button is pressed. The complete bearing performance results can be generated for a *Single-Case* or *Multiple-Cases* with user specified operating conditions of Load, Speed, Viscosity, Supply Lubricant Flow Rate, Temperatures, Pressure, Orifice/Nozzle Geometry, etc.

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

Single Case results are displayed here after the Run button is pressed.

Ok Cancel Help

Lubricant Properties can be selected from the built-in lubricant database or specified by the user. User specific lubricants, not available in the database, can be added for later retrieval and use.

Lubricant Properties

Choose Lubricant

Supplier Typical
Brand Name ISO Grade 32 Oil
ISO Grade 22
API Gravity 31.0

Kinematic Viscosities (for interpolation)
1st Point 32.0 1st Temperature 104.0
2nd Point 5.36 2nd Temperature 212.0
Reset

Lubricant Library

	Supplier	BrandName	ISO Grade	API Gravity	1st Kinematic Viscosity Point	1st Kinematic Viscosity Temp.	2nd Kinematic Viscosity Point	2nd Kinematic Viscosity Temp.
87	TEXACO	REGAL R&O 220	220	26.7	220.0	104.0	18.1	212.0
88	TEXACO	REGAL R&O 320	320	26.1	320.0	104.0	23.1	212.0
89	TEXACO	REGAL R&O 460	460	25.0	460.0	104.0	29.1	212.0
on	TEXACO	REGAL R&O N-100	100	22.0	100.0	104.0	9.0	212.0
	TEXACO	REGAL R&O N-68	68	22.9	67.0	104.0	7.2	212.0
	TOTAL	PRESLIA 100	100	28.206	99.3	104.0	11.4	212.0
	TOTAL	PRESLIA 32	32	31.144	32.3	104.0	5.4	212.0
	TOTAL	PRESLIA 46	46	30.214	46.3	104.0	6.8	212.0
	TOTAL	PRESLIA 68	68	28.568	67.4	104.0	8.7	212.0
	Typical	ISO Grade 10 Oil	10	33.4	10.0	104.0	2.66	212.0
	Typical	ISO Grade 15 Oil	15	32.6	15.0	104.0	3.41	212.0
	Typical	ISO Grade 22 Oil	22	31.8	22.0	104.0	4.29	212.0
	Typical	ISO Grade 32 Oil	32	31.0	32.0	104.0	5.36	212.0
	Typical	ISO Grade 46 Oil	46	30.3	46.0	104.0	6.76	212.0

Save Select Cancel Help

ARMD™ V6.1 – TILTBR Module

Feed-Nozzles: Feed nozzles numbers and orifice geometry may influence the bearing performance significantly. For tilting pad feed nozzles the flow is controlled by the number of feed nozzles and their orifice diameter. Due to supply lubricant pressure, these flow rates impact the heat balance and temperature rise through the bearing which in turn influences the oil film viscosity, thus affecting bearing performance.

Simulation with the latest version can include the influence of a pressurized nozzle feeding system, or classical flow assumption (non-starved lubrication). By default, classical flow is simulated by assuming that the bearing's supply flow rate is equal to its side leakage flow rate as a minimum, or the simulation will utilize the user specified supply flow rate.

For pressurized lubricant supplied through sharp-edge orifices/nozzles (typically incorporated in tilting pad bearings) the supply pressure, number of orifices/nozzles per pad and orifice/nozzle geometry are to be specified by the user.

Images of pressure fed tilting pad journal bearing are shown below for a single (one) feed-orifice/nozzle per pad and a three feed-orifices/nozzles per pad.



For “**Pressurized**” flow type, the supply pressure, number of orifices/nozzles per pad and orifice/nozzle geometry are specified by the user.

Single Case Lube Details

Lubricant Conditions

Solve For: Film Temp

Film Temperature: 0.0

Supply Temperature: 120.0

Flow Type: Pressurized

Supply Flow Rate: 0.0

☐ User Specified Viscosity and Heat Content

Viscosity / Heat Content

Viscosity: 0.0

Heat Content: 0.0

Pressurized Feeding System

of Orifices per Pad: 1

Supply Pressure: 20.0

Orifice Discharge Coeff.: 0.0

Orifice Diameter: 0.118

Ok Cancel Help

Lube Supply Pressure: psig

Pressurized
Classical
Pressurized

ARMD™ V6.1 – TILTBR Module

Single Case: 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

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	<input type="checkbox"/>

Single Case
Multiple Cases
Lubricant Properties

1 of 20
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

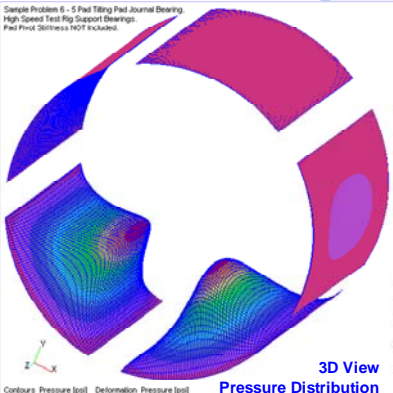
Min. Film Thick. -> 9.8316E-04 (Inch) | ECC = 0.6344 @ Angle = 270.00 (Deg)
 Power-Loss ----> 2.5591E+01 (HP) | Side-Leakage QF -> 1.7102E+00 (Gpm)
 Load Capacity --> 4.9955E+03 (Lbf) | Inlet-Flow QI -> -1.5409E+01 (Gpm)

 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 (Reyn) |-----
 Heat Content ----> 3.622 (BTU/G/F) |>>> DAMPING (Lbf-Sec/Inch)
 Groove Temp. ----> 165.765 (Deg.F) | DXK ; DXY --> 1.637E+03 3.463E-04
 Max. Temp. (avg.)-> 186.347 (Deg.F) | DYX ; DYY --> 1.420E-04 2.551E+03

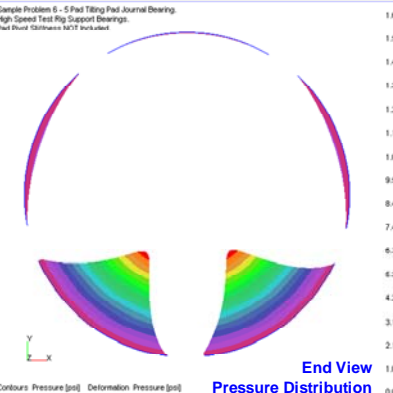
 Individual Pad Results Below-----
 Surface Velocity= 1.833E+04 (Ft/min) | Projected Pressure= 5.709E+02 (PSI)

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)

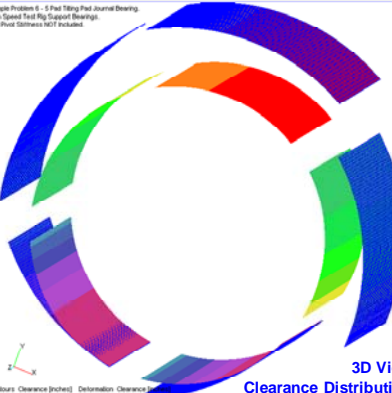
Pad No.	Sump/Groove Temp. (deg F.)	Avg-Film Temp. (deg F.)	Max-Film Temp. (deg F.)	Min-Film Thickness (inch)	Power Loss (hp)	Side Leakage (gpm)
1	1.7247E+02	1.7550E+02	1.7853E+02	3.8107E-03	2.4191E+00	1.1370E-01
2	1.6620E+02	1.7180E+02	1.7740E+02	2.5828E-03	3.3132E+00	3.9459E-01
3	1.6167E+02	1.9445E+02	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



3D View
Pressure Distribution



End View
Pressure Distribution



3D View
Clearance Distribution

ARMD™ V6.1 – TILTBR Module

Multiple Cases / Parametric Evaluation : Multiple case bearing performance evaluation can be performed as a function of any combination of user defined operating conditions of Clearance, Speed, Load, Viscosity, Flow Rate, Temperatures, Pressure, feed orifices, etc.

Parametric evaluation of bearing performance is accomplished efficiently.

Expand button if pressed will expand the window to the full width of the parent window which provides a quick view of all the columns for efficient data entry and modifications.

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

Expand Run

	Radial Clearance	Preload	Load	Speed	Load Angle	Groove Angle	Orientation Angle
1	0.004	0.4	5000.0	20000.0	270.0	0.0	90.0
2	0.004	0.4	5000.0	19000.0	270.0	0.0	90.0
3	0.004	0.4	5000.0	18000.0	270.0	0.0	90.0
4	0.004	0.4	5000.0	17000.0	270.0	0.0	90.0
5	0.004	0.4	5000.0	16000.0	270.0	0.0	90.0

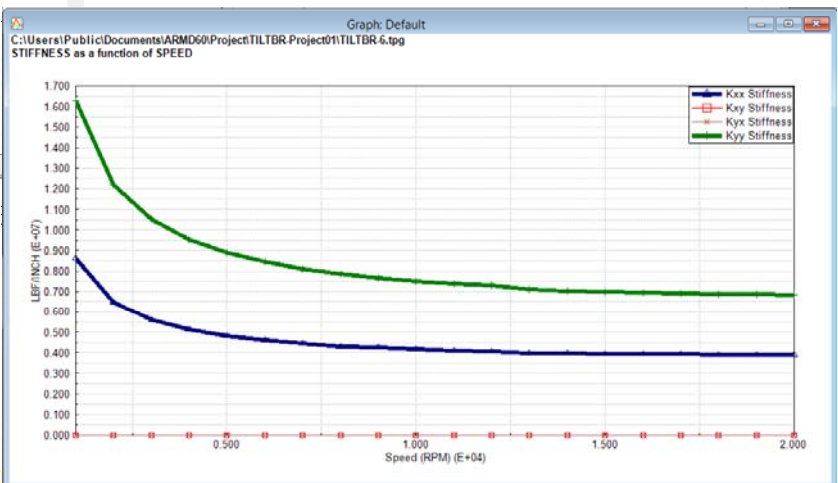
	Radial Clearance	Preload	Load	Speed	Load Angle	Groove Angle	Orientation Angle	No. of Pads	Use Lubricant Viscosity / Heat Content	Specified Viscosity	Specified Heat Content	Film Temperature	Supply Temperature	Flow Rate	Supply Pressure	Flow Type	Number of Orifices per Pad	Orifice Diameter	Orifice Discharge Coefficient
1	0.004	0.4	5000.0	20000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0
2	0.004	0.4	5000.0	19000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0
3	0.004	0.4	5000.0	18000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0
4	0.004	0.4	5000.0	17000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0
5	0.004	0.4	5000.0	16000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0
6	0.004	0.4	5000.0	15000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0
7	0.004	0.4	5000.0	14000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0
8	0.004	0.4	5000.0	13000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0
9	0.004	0.4	5000.0	12000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0
10	0.004	0.4	5000.0	11000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0
11	0.004	0.4	5000.0	10000.0	270.0	0.0	90.0	5	<input type="checkbox"/>	0.0	0.0	0.0	120.0	0.0	20.0	Pressurized	1	0.118	0.0

Case Number	Preload Ratio	Rotational Speed (Rpm)	Viscosity LBF-SEC/IN ²	Heat Content BTU/G-Deg F	Temperature Film (Deg F)
1	0.400	2.0000E+04	0.0000E+00	0.0000E+00	1.4400E+02
2	0.400	1.9000E+04	0.0000E+00	0.0000E+00	1.4400E+02
3	0.400	1.8000E+04	0.0000E+00	0.0000E+00	1.4400E+02
4	0.400	1.7000E+04	0.0000E+00	0.0000E+00	1.4400E+02

Case Number	ECC Ratio	Minimum-Film Thick. (Inch)	Load (Lbf) Capacity	Angle-to-Eccentricity	Power-Loss (HP)
1	0.634	9.8316E-04	4.9955E+03	2.7000E+02	2.5591E+01
2	0.637	9.7755E-04	5.0008E+03	2.7000E+02	2.4095E+01
3	0.641	9.7195E-04	4.9982E+03	2.7000E+02	2.2589E+01
4	0.645	9.6649E-04	5.0019E+03	2.7000E+02	2.1005E+01
5	0.648	9.5793E-04	4.9952E+03	2.7000E+02	1.9573E+01
6	0.654	9.4881E-04	4.9985E+03	2.7000E+02	1.8068E+01
7	0.659	9.3829E-04	5.0019E+03	2.7000E+02	1.6564E+01
8	0.666	9.2707E-04	4.9954E+03	2.7000E+02	1.5060E+01
9	0.684	9.2400E-04	5.0029E+03	2.7000E+02	1.3160E+01
10	0.694	8.7657E-04	5.0015E+03	2.7000E+02	1.1724E+01

Case Number	Supply-Oil Temp. (Deg F)	Lub. Film Temp. (Deg F)	Film-Viscos. LBF-SEC/IN ²	Groove Temp. (Deg F)	Max Temp. ()
1	1.2000E+02	1.7606E+02	1.0175E-06	1.6576E+02	1.86
2	1.1999E+02	1.7340E+02	1.0582E-06	1.6318E+02	1.83
3	1.2000E+02	1.7071E+02	1.1019E-06	1.6059E+02	1.80
4	1.1999E+02	1.6799E+02	1.1486E-06	1.5796E+02	1.78
5	1.1999E+02	1.6524E+02	1.1989E-06	1.5533E+02	1.75
6	1.1999E+02	1.6247E+02	1.2525E-06	1.5269E+02	1.72
7	1.2000E+02	1.5969E+02	1.3104E-06	1.5006E+02	1.69
8	1.2000E+02	1.5695E+02	1.3724E-06	1.4742E+02	1.66
9	1.1999E+02	1.5668E+02	1.3770E-06	1.4329E+02	1.70
10	1.2000E+02	1.5385E+02	1.4433E-06	1.4080E+02	1.66
11	1.2000E+02	1.5102E+02	1.5149E-06	1.3832E+02	1.63
12	1.1999E+02	1.4818E+02	1.5917E-06	1.3589E+02	1.60
13	1.2000E+02	1.4531E+02	1.6748E-06	1.3351E+02	1.57
14	1.2001E+02	1.4246E+02	1.7634E-06	1.3121E+02	1.53
15	1.2001E+02	1.3959E+02	1.8593E-06	1.2900E+02	1.50
16	1.2001E+02	1.3674E+02	1.9617E-06	1.2691E+02	1.46
17	1.2000E+02	1.3388E+02	2.0725E-06	1.2495E+02	1.42
18	1.2001E+02	1.3107E+02	2.1902E-06	1.2323E+02	1.38
19	1.2001E+02	1.2824E+02	2.3174E-06	1.2175E+02	1.34
20	1.2001E+02	1.2533E+02	2.4597E-06	1.2062E+02	1.30

Multiple case bearing performance results are automatically displayed in text format as illustrated below. The ARMD graphics utility can be used to display X-Y plots of any of the generated results.

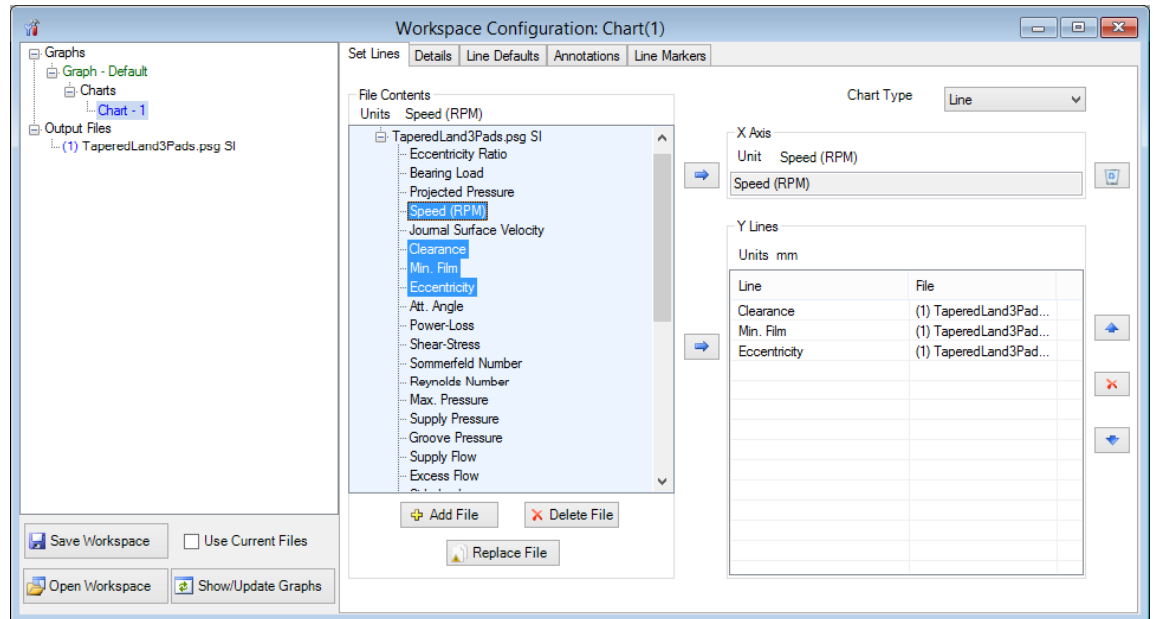


2-D Graphics Utility ([ARMDGraph](#))

[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.

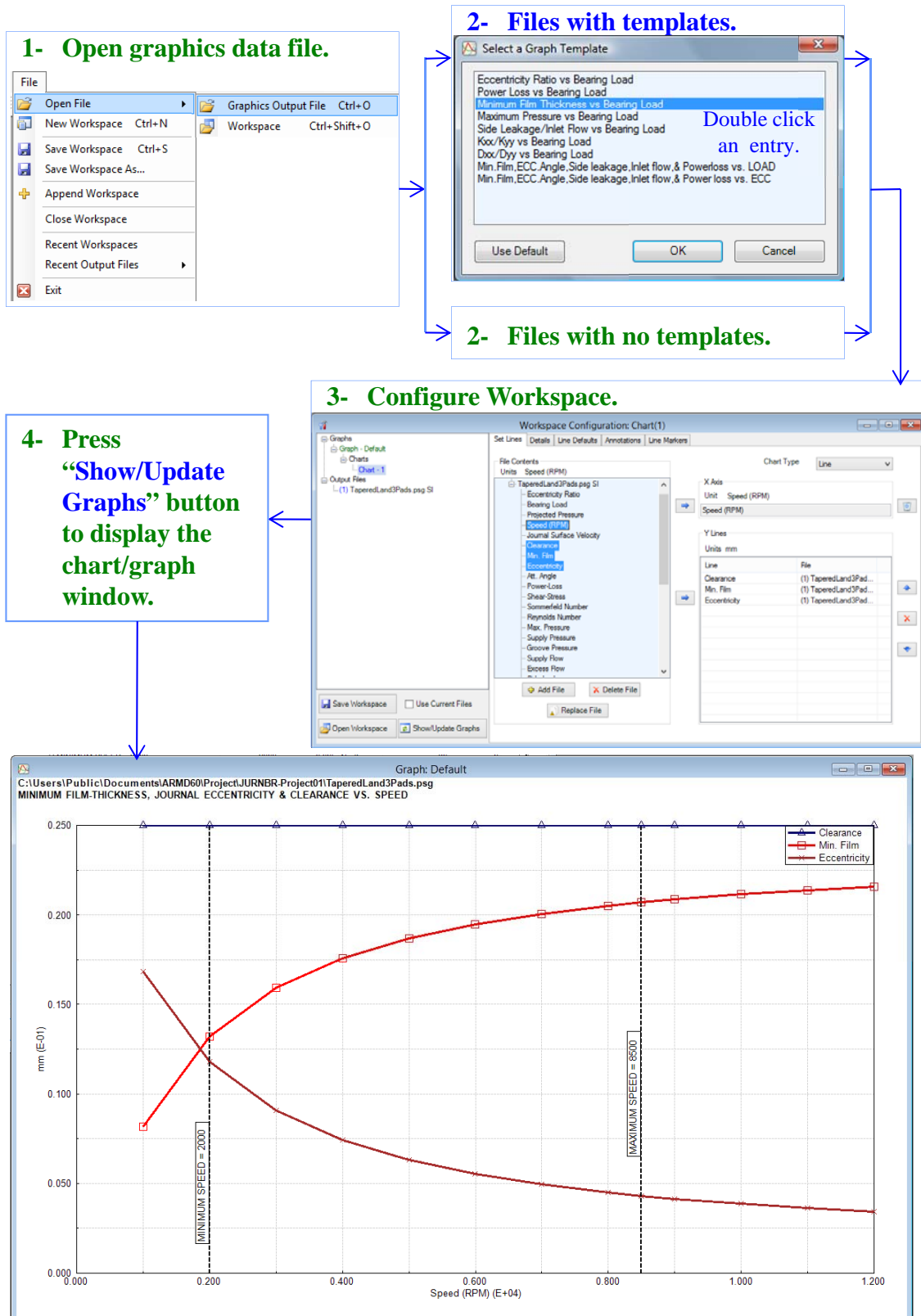


ARMDGraph features include:

- 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 (hot 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.
 - Grid lines (ON or OFF).
 - Draw curves with lines, symbols or both.
 - Automatic or manual axis scaling.
 - Legend position (hidden, inside or outside right).
 - 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

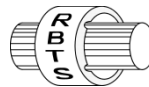
ARMD is constructed from various solution modules. It can be tailored to suit your needs and budget. You may purchase any combination of programs/modules or all if you wish. Licensing is available as a single seat or multi-seat network configuration. With your purchase, the package includes the software (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 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.



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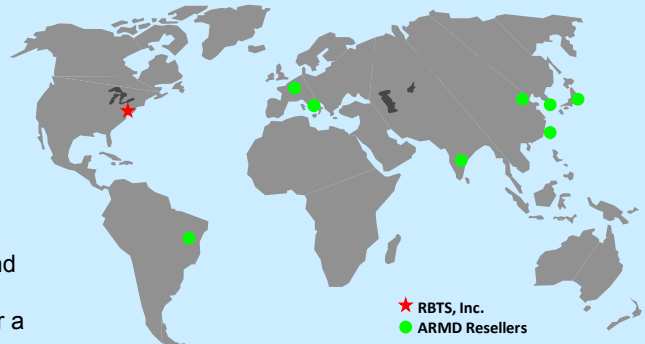
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Advanced Rotating Machinery Dynamics

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- ♦ **Technical Capabilities**
- ♦ **User Friendliness**
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