

## Fixed & Tilting-Pad Fluid-Film Lubricated Thrust Bearings



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

**Dr.-Ing. Andreas Laschet · Apolloniaweg 6 · 51515 Kuerten · GERMANY** Phone: +49 2268 901650 · E-mail: <u>info@laschet.com</u> · Web: <u>www.laschet.com</u>





The fluid-film bearing module **THRSBR** 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 the fixed and tilting pad configuration. Complete performance predictions of **hydrodynamic**, **hydrostatic**, and **hybrid** lubricated thrust bearings operating in the laminar and/or turbulent regimes can be generated. Analysis starts with subdividing the bearing/pad surface area into grid pattern in two dimensions (circumferential & radial) and establishing the lubrication system of equations. Boundary conditions (pressurized boundaries, pockets, lines, recesses with specified pressures, surface deviation, etc.) are incorporated to the system of equations. 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 fixed and tilting pad geometries thrust bearings that can be analyzed include but not limited to:

		Right Hand Coordinate	Misalirnment with Bearing Surface	◆ - Step-Pad Configuration
a.	Plain surface	System Pad Inner	Rotation	Pad
b.	Multi-groove	Radius	Styry Y	Inner Radius
C.	Step pad	Outer Radius Pad Toronow Pad	Shaft Thrust Collar	
d.	Step pocket	Angie Y	h=C+AMISY*Ro h=C-AMISY*Ro	Clearance Rotation Shaft Pyroperty Step Height
e.	Tapered land	Rotation Shaft Thrust Collar	Misalignment is about coordinate system origin (AMISY = Misalignment about Y-axis)	Section A-A
f.	Tapered pocket	◆ - Shrouded Step-Pad Configuration		◆ - Shrouded Tapered-Land Configuration
g.	Tilting pad	Pad	Pad	Pad
h.	Compound taper	Inner Radius Outer	Radius Outer Pacifics	Inner Radius Outer
i.	Any configurable	Pad #3 Colores Pad Ange #3	Pad 83 Appa	Radius Pad #3
	pad surfaces	Rotation Shart Participation Couter Side Land i Pad Angle Pad Angle Pocket	Clearance Rotation Shaft Rynner Taper Height	Rotation Shaft
		Section AA	Section A-A	E Contraction AA
		◆ - Tilting-Pad Configuration	◆ - Compound Taper	- Any Configurations utilizing
		Tree to the second seco		1.885 1.985 3.326 4.965
		Shaft Rotation (Runner)		1 mo d 1 Kod 2 mo d 2 mo d 2 mo d
		Clearance Pad Tilt		
				Veneza Connector de La Connector (INERCEPTRAT) Competitiva Connector de Connector d

RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA ● Tel:610-415-0412 ● info@rbts.com ● www.rbts.com

Page 2 of 21

Simulation capabilities with **THRSBR** include such effects as misalignment, pressurized boundaries or grooves, structural deformation/surface deviation, lubricant feed circuitry with specified pressures and feed orifices/nozzles, groove geometry and chamfers to mention a few. Performance results include the following.

- Load capacity
- Runner position
- Viscous power loss
- Righting moments

- Flow requirements
- Stiffness and damping (dynamic) coefficients
- Clearance and pressure distribution
- Heat balance and temperature rises





Page 3 of 21

The release of RBTS' **ARMD Version 6 THRSBR** 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. THRSBR 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 THRSBR 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 select from many standard bearing types (Plain, Multi-groove, Rayleigh Step or Pocket, Tapered Land or Pocket, Tilting Pad, etc.), restricting input to only those fields pertinent to that type, along with a user-defined selection that allows the user complete freedom in configuring pad 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 any bearing pad surface configuration and apply it to all pads in the bearing. This capability provides means for the user to model any pad surfaces they desire or would like to experiment with.

Version 6 THRSBR 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 steps, tapers, specified pressure regions, tec.) 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.

Surface deviation for customized and unique bearing internal clearances (compound tapers, special grooving, structural deflection/deformation, tilting pad deflection, full or partial radially tapered surfaces, etc.) incorporates import function of CSV (comma separated variables) files containing clearance deviations for the custom bearing design.

#### 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.



> Multiple instances of THRSBR. The newly developed package can now open simultaneous

multiple instances of THRSBR, so side-by-X THRSBR (C:\Users\Public\Documents\ARMD58\TH... side comparison of bearings model Bearing File Edit Options Run View Project Window Help variations and analysis results are easy and 01218 λ 🖻 хI 1日 efficient. This functionality permits multiple THRSBR V5.8 - - - X instances of THRSBR Version 6 or Version Pad Radial Grid Intervals Gearbox 14-Pad 5.8 to be accessible on your display, from Length Tapered Land which portions of a model (grid layout, 1.075765e+001 surface deviation, etc.) can easily be moved 1.075765e±001 from one instance to another. 🛟 Thrsbr (C:\Users\Public\Documents\ARMD60\Project\THRSBR-Project01\TaperedLandShrouded14Pa... 🗕 🗖 💌 Edit Bearing Options Advanced | Run Analysis | Post-Processor View Tools Window Project 🛅 New 쯜 Open 🚽 Save 🛛 😹 Cut 鶅 Copy 鶅 Paste 🗏 😨 Bearing Model 🖽 Pad Grid Model 🛛 Insert Value: Thrsbr (C:\Users\Public\Documents\ARMD60\Project\THRSBR-Projec ٢ - • × Bearing File Edit Bearing Options Advanced Run Analysis Post-Processor THRSBR V6 Instance #2 🎦 New 📄 Open 🚽 Save | 👗 Cut 🌊 Copy 🖺 Paste || 😨 Bearing Model 🏼 Pad Basic Geometry Misalignment Pad Config Operating Conditions Pad Grid Pad Grid With Features (Display Only) Gearbox 14-Pad Tapered Land Pad Profile ٢ Advanced Pad Geometry Boundary Pressures Static Pressure Points / Pockets Surface Deviation Number of Pads 14 20.0 Pad Angle Enable Surface Deviation Set Size Import Magnitudes Pad #1 Orientation Angle 0.0 0.0 Groove Angle [C001: 1.75, R001: 29.0] The deviation grid is a Inner Radi Radial and Circumferential Locations Deviation Magnitudes Step/Taper/Pocket Tilting Pad Radial Locations View Increments Outer Radius Locations Side 1 Land / Step 20 Side 2 Land / Step 13.0 38.0 Step / Taper Height 0.05 2 47.0 3 THRSBR V6 Instance # 1 Step 📃 Taper 🗸 ter Side Li nale Step Angle 18-Pad Tilting Pad with Pad Pocket Taper Any Anale Taper Angle Deflection/Deformation 16.5 Pad Angle Shrouded Tapered-Land Configuration Cancel -10 Ok Cancel Help No License No License THRSBR-Project01

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.



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

Pre-Configured Bearing and Types. 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 illustration (shown below) it takes only five steps utilizing templates/wizard to model a bearing with its geometry and operating speed and provide a complete solution of bearing performance.

14 Pad Tape	ered Land Thrust Beari	ing With Shroud.	with Shroud -		
Please enter Outer Radi (mm)	Please enter Inner Radiu (mm)	14 Pad Tapere Please enter Bearing Clearance / Gap Limit (mm) 125 <a href="https://www.sec.enter.ente</td> <td>ed Land Thrust Bearing          ed Land Thrust Bearing         14 Pad Tapere         Please enter Taper Height (mm)         (050)         &lt; Back</td>	ed Land Thrust Bearing          ed Land Thrust Bearing         14 Pad Tapere         Please enter Taper Height (mm)         (050)         < Back	With Shroud. – – – – – – – – – – – – – – – – – – –	Shroud  Ind Thrust Bearing With Shroud  Shrouded Tapered-Land Configuration - 14 Pads Shrouded Tapered-Land Configuration - 14 Pads Index State Land Outer

Bearing Pad Configuration. A vastly improved pad configuration tab allows the user to select from many standard bearing types, including special options, while restricting input to only those fields/cells pertinent to that type. To assist the user when a pad profile has been selected, various fields/cells in the form will appear and be accessible or grayed out as shown below for the tapered land profile. When a "User Defined" pad profile is selected, the user has complete freedom in configuring pad attributes.

User Defined	•
Stepped Pad	
Tapered Land	
Tilting Pad	
User Defined	

•				Bea	ring			×
Ba	asic Geometry	Misalignment	Pad Config	Operating Conditions	Pad Grid	Pad Grid With Features (Display Only	0	
D	Pad I Pad Geo Numb Pad <i>I</i> Pad <i>I</i> Groov Step/Tape Side Side Step Inclus Step	Profile ometry ber of Pads Angle #1 Orientation Ar ve Angle r/Pocket Tiltir 1 Land / Step 2 Land / Step / Taper Height de Angle r Angle	ngle	Image: Conditions         Image: Conditions         Image: Conditions         14         20.0         0.0         0.0         0.0         13.0         0.05         Image: Conditions         Image: Conditions <th></th> <th>Pad Gind with Features (Display Only Pad Pad Pad Pad Pad Pad Pad Pad Pad Pad</th> <th>Pad Pad Pad Pad #1 Inner Side Land + Inner Side Land +</th> <th></th>		Pad Gind with Features (Display Only Pad Pad Pad Pad Pad Pad Pad Pad Pad Pad	Pad Pad Pad Pad #1 Inner Side Land + Inner Side Land +	
				Ok	Cance	Help		2

#### > Features Defined by Geometry.

The newly developed package incorporates built-in analytical routines to accommodate bearing pad design **feature locations** (like steps, tapers, and lube feed specified pressure regions) locations by their physical location in normal design length units (**millimeter**, **inch**, **degree**, etc.), not by grid point index as in previous versions. This significantly enhances bearing/pad model development and provides the user with an efficient means to incorporate bearing/pad design features of interest.

Step/Taper/PocketTilting Pad			
Side 1 Land / Step Side 2 Land / Step Step / Taper Height	2.0 13.0 0.05	Tilting Pad	
Include Step Angle Taper Angle	Step Taper  0.0 16.5	jle dius dial ngential	8.25 0.0 0.0 0.0
	Calculate Truncation co No. of iteration	tilt of tilting pad nstant for tilt angle ns to solve for tilt	0.001

RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA ● Tel:610-415-0412 ● info@rbts.com ● www.rbts.com

Bearing Pad Grid. 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 default setting. As illustrated below, 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.

\$	>		Bea	aring					
	Basic Geometry Misalignment	Pad Config	Operating Conditions	Pad Grid Pa	ad Grid With Fea	atures (Dis	play Only)		
		Radial Grid F	oints		Circ	cumferenti	al Grid Points		
	Grid point 1 at location		Increment	Location	^		Increment	Location	^
	o is not alterable and is not shown.	2	0.5	0.5		28	0.5	13.5	
		3	0.5	1.0		29	0.5	14.0	
	Show Increments	4	0.5	1.5		30	0.5	14.5	
		▶ 5	0.5	2.0		31	0.5	15.0	
	Current Grid Size	6	0.5	2.5		32	0.5	15.5	
	Pad Grid:	7	0.5	3.0		33	0.5	16.0	
	Radial: Circ:	8	0.5	3.5		34	0.5	16.5	
	31 41 With Easturge:	9	0.5	4.0		35	0.5	17.0	
	Radial: Circ:	10	0.5	4.5		36	0.5	17.5	
	31 41	11	0.5	5.0		37	0.5	18.0	
		12	0.5	5.5		38	0.5	18.5	
		13	0.5	6.0		39	0.5	19.0	
	Generate Grid	14	0.5	6.5	•	40	0.5	19.5	
	Validate/Repair Grid	15	0.5	7.0	V L	41	0.5	20.0	~
6	-621		Ok	Cancel	Help				<b>(</b>
R	adial Point Increment						mm		
			🔅 Ge	enerate Grid	- 🗆 ×		🕽 Ge	enerate Grid	- 🗆 🗙
		>	Grid Type	0.14	ser Specified	$\rightarrow$	Grid Type	Ilser	Specified
Г		<u> </u>	C) Dordak	0 00		σ	Oboldak	0 000	opeened
	If a grid point increme	ent <u>S</u>	Default Grid Density	Medium	High	ifie	Default Grid Density	Medium	High
	a mismatch between	n   🖏	26X27	37X37	73X73	bec	26X27	37X37	73X73
	the size of the grid ar	art bi	User Specified Grid			N N	User Specified Grid		
	the size of the bearing, a single button click will		Number of Radial Point	s Number of Circu	imferential Points	S	Number of Radial Points	Number of Circumf	erential Points
			31		41		31		41
	proportionately resize the grid to fit the bearing	;	If you click Generate, a discarded. If you have d pressure regions, the gri to include those location	new grid will be built a lefined recesses, pum d you specified here n ns as needed.	and any old grid nps, or static will be expanded		If you click Generate, a n discarded. If you have de pressure regions, the grid to include those locations	new grid will be built an efined recesses, pumps I you specified here will s as needed.	d any old grid s, or static be expanded
L	boaring		Generate	Canc	cel		Generate	Cancel	

Clearances – Options Form. Thrust runner to bearing surface clearances/gaps for bearing performance simulation is specified in the Options form shown below. Clearances are automatically generated (10, 24, 50 default, 100 clearances, or can be specified by the user) for user specified axial clearance/gap limit and pressing the Generate button. Modified axial gaps can simply be entered and clearances for simulation updated with the Generate button at any time.

;	•		Opt	tions						×
	Description	Clearances	Output and Solver Controls							
				_						
						Scaling	Clearances	^		
			Bearing Clearance / Gap Limit:	►	1	1.0	0.125			
			0.125		2	0.975	0.121875			
			Default Scaling Factors		3	0.95	0.11875			
			👝 Generate Default		4	0.925	0.115625			
			Scaling Factors Set		5	0.9	0.1125			
			10 factors		6	0.875	0.109375			
			24 factors		7	0.85	0.10625			
			<ul> <li>50 factors</li> </ul>		8	0.825	0.103125			
			100 factors		9	0.8	×	Cut	Ctrl+X	
			0		10	0.775	0.09	Сору	Ctrl+C	
					11	0.75	0.0	Paste	Ctrl+V	
			Generate		12	0.725	0.09 🞧	Clear		
					13	0.7	0.			
					14	0.675	0.08	Insert Row	F3	
							4	Append Row	Ctrl+F3	
							×	Delete Row	F4	
	[_tat]		Ok	C	ancel	Help	<u>۶</u>	Duplicate Roy	w F5	
			OK		ancer	Ticip				
1										

# Output and Solver Controls – Options

Form. Version 6 provides the user with condensed, intermediate and detailed output results of the solution with simply selecting the appropriate radio button. Additionally and unlike previous version **restore default button** provides default settings on increments for stiffness and damping coefficients to be generated.

<b>)</b>	Options	
Description Clearances Output	t and Solver Controls	
	Output Files Oundensed      Intermediate     Generate non-dimensional text output fil	O Detailed
Dynamic Perturbations Spring Coefficients X-axis Displacement	0.00E Y-axis Displacement 0	0.005 Z-axis Displacement -0.005
Damping Coefficients X-axis Velocity	0.005 Y-axis Velocity 0	0.005 Z-axis Velocity -0.005
Tilting Pad Angular Displacem About radial axis	ents 0.005 About tangential axis 0	1.005
- Leal	Restore Defaults For These Values	
	UK Cancel	

Page 10 of 21

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 a 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 radial and circumferential positions) in the bearing pad surface area, unlike previous versions which permitted only the specification of pressures at already established grid points.

•				Advanced				
Boundary	Pressu	res S	itatic Pressure Poin	ts / Pockets Su	rface Deviation			
			Radial 1	Radial2	Circ1	Circ2	Pressure	
		1	0.5	0.5	5	5	100.0	Specified pressure point
		2	0.5	0.5	45	45	100.0	— Specified pressure point
	•	3	1	2	20	30	100.0	Specified pressure box
		4	2.5	2.5	5	5	100.0	Specified pressure point
		5	2.5	2.5	45	45	100.0	Specified pressure point
				Ok Ca	ancel Hel	p		
Radial Poin	nt Loca	ation 1				i	nch	

The above specified conditions illustrate (shown pictorially below with the display of the pad grid layout) the specification of points pressure at a radial location of 0.50 inches and located at 5 and 45 degrees circumferentially, points pressure at a radial location of 2.5 inches and located at 5 and 45 degree circumferentially, as well as pressurized pocket/box bounded radially at 1.0 and 2.0 inches, and circumferentially at 20.0 and 30.0 degrees.



Surface Deviation – Advanced Form. Surface deviation is defined as modification to the bearing fluid-film clearance distribution. The surface deviation magnitudes are superimposed clearances to the geometrical clearance distribution of the bearing surface. This surface deviation is a fixed magnitude of superimposed clearances to the geometrical clearance distribution of the bearing or pad surfaces regardless of shaft/runner position in the bearing clearance due to applied load, speed, viscosity, etc. With this capability and in addition to standard configuration bearings such as step, step pocket, tapered-land, tapered-pocket, tilting pad, etc., practically any bearing/pad surface geometry imagined (compound taper, full or partial radial/circumferential tapered or wavy surfaces, structural deformation or deflection, etc.) can be modeled and evaluated with the software.

When surface deviation feature is enabled by checking the "Enable Surface Deviation" box (shown below), the form expands allowing grid network size to be specified and grid intervals in the radial and circumferential directions computed. Surface deviation may also be imported from external comma-separated-files (.CSV files).

-	Surface Deviation – 🗆 🗙	Advanced
	Surface Deviation	Boundary Pressures Static Pressure Points / Pockets Surface Deviation
	Build Default Matrix from Pad Grids	✓ Enable Surface Deviation         Set Size         Import Magnitudes         Repair Grid         Current Grid Size:         Current Circumferential         3
	Clear existing surface deviations	[C001: 1.75, R001: 29.0 ] The deviation grid is a Global Grid v and applies to the whole bearing.
	Grid Dimensions	Radial and Circumferential Locations Deviation Magnitudes
	Points: Location: Location:	Radial Locations
	Radial Direction:         3         29.0         47.0	Increments Locations Increments Locations
	Circumferential Direction: 5 1.75 18.25	
		3 9.0 47.0 3 4.125 10.0
•	Hydro-Power Tilting Pad Deflection Advanced	
Bou	undary Pressures Static Pressure Points / Pockets Surface Deviation	5 4.125 18.25
R	Participation         Set Size         Import Magnitudes         Repair           [C001: 1.75, R001: 29.0]         The deviation grid is a Global Grid         v and applies to additional and Circumferential Locations         Deviation Magnitudes	ar Grid       Current Grid Size:       Radial Circumferential       3 Circumferential       Surface Deviation Grid - C\UserS\Public\Documents\ARMDocurrents\ARMDocUrrentSRe.v:
	C001 C002 C003 C004	C005 Min. Circuin. Location: 175 degrees
	▶ R001 -0.001 -5.000000e-04 0.0 -5.000000e-04	14 -0.001 Max Groun Location:
	R002 -0.001 -5.000000e-04 0.0 -5.000000e-04	14 -0.001 Min. Radia Location:
	R003 -0.001 -5.000000e-04 0.0 -5.000000e-04	23 0 inches Max. Radial Location;
		47.0 inches
	Ok Cancel	Help 15.5 degrees
Devi	ations	inch
	Two options are available for defining the deviation in version 6 of the thrust bear 1- By default (shown above) the surface	the surface ring Module:
	specified in the global bearing coord "Global Grid" and not the individual p The deviation grid is a Global Grid	pad grid network.
	2- Surface deviations may be specified	d over one pad surface area (1 <sup>st</sup> pad closest to the X-axis)

applied to all pads in the bearing when selecting the "Single

Single Pad The deviation grid is a and will be duplicated to all pads

#### A view of the pad grid network and the bearing graphical presentation are shown below.



Specified surface deviations/deformation applied in the global coordinate system (Global Grid) and the actual surface deviation extended in the circumferential direction to cover one pad only. Performing the bearing solution, generating the bearing performance results, and viewing the fluid-film pressure/clearance distributions, the surface deviations will be considered in the 1st bearing pad only as shown below.



If the specified surface deviations (pad deformation) is used on all pads by simply selecting the "Single Pad" option, performing the bearing solution will consider the deviations in each of the pads and produce the bearing performance results with the fluid-film pressure and clearance distributions shown below.



RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA ● Tel:610-415-0412 ● info@rbts.com ● www.rbts.com

- 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.
- 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.
- 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.

Enable Units Conversion from Expression Evaluator
 Enable Rounding Button
 Set Rounding Precision

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

•		Thrsbr (C:\Users\Put	olic\Documents\ARMD60\Project\THRSBR-Pr	roject01\Tap	peredLandShrouded14PadThrustBearingSample01.thi SI)	
File Edi	t Bearing Options Ac	dvanced   Run Analysis   Post-Pro	ocessor View Tools Window Project Help	p		
🎦 New 📔	Open 🛃 Save   👗 Cut 😭	🖁 Copy  🏝 Paste 🛛 😨 Bearing Mod	el 🏢 Pad Grid Model   Insert Value:			
0		Bearing	-		🗘 Post-Processor 🗖	
Basic G	eometry Misalignment Pad Co	onfig Operating Conditions Pad Grid P	ad Grid With Features (Display Only)		Description	
	Dead Deathle				GEARBOX Fluid-Film THRUST BEARING ANALYSIS. 14 PAD SHROUDED TAPERED LAND.	
	Pad Geometry	Stepped •	Y.		Bearing Performance Including Pressure Distribution @ 15000 RPM.	
	Number of Pads	14	a y			
	Pad Angle	20.0			R-Outer 50.0 R-Inner 35.0 Number of Pads	14
	Pad #1 Orientation Angle	0.0	Pad #1		Min Clearance 0.00125 Rotational Speed 15000.0 Viscosity 6.8947	58e-03
	Groove Angle	0.0	Inner			
	an (Teners (Destant) Titles Pad		Radius		Single Case   Multiple Cases   Lubricant Properties	
St	ep/Taper/Pocket Titting Pad				🚺 🚽 9 of 12 🕨 🔰 💠 📉 Lube/Chamfer 🍠 Run 3D	)
			Outer a <sub>x</sub>	^	Operating Conditions	
	Side 1 Land / Step	2.0	Radius		Clearance 0.025 Speed 15000.0 Load 0.0	
	Side 2 Land / Step	13.0	Pad Pad			
	Step / Taper Height	0.05	Angle		Operating C> 0.025000 (mm)   Min.Film Thick> 0.025000 (mm)	^
	Include	Step 🖌 Taper	Rotation (Rynner)	nd	Max. Pressure> 2.936E+06 Pascal   Side-Leakage QF -> 2.391E+00 (L/min)	
	Step Angle	0.0	Bearing Pad	7	through ID -> 9.591E-01 (L/min)	
			Step Angle		Supply-Oil Temp.> 50.001 (Deg.C)   Inlet-Flow QI -> -1.378E+01 (L/min)	
	l aper Angle	16.5	Pad Angle 0/1 Pad#1	* 10	Supply Flow Rate> 5.000E+00 (L/min)  >Max. Reynolds # -> 6.443E+02 Film-Temp> 77 121 (Deg C)	
			Shrouded Step-L and Configuration		Viscosity> 7.585E-03 (Pa-Sec)  > A X I A L	
			Childradd Orap Lana Conngalaiten		Groove Temp> 72.238 (Deg.C)   Stiffness (Newton/m) = 1.894E+08 Max. Temp> 82.004 (Deg.C)   Damping (Newton-Sec/m) = 3.456E+04	
-60		Ok Cancel	Help	<b>(</b>	BRGVU - [thrpost.thv]	
					File Edit View Contours Deformations Display Zoom Rotate Colors Window Help	_ & ×
Ļ			·			
🛟 Beari	ing Model - C:\Users\Pu	blic\Docum 🗖 🗉 🖾	I Pad Grid - C:\Users\Public\Docu	• 🛛	GEARBOX Fluid-Film THRUST BEARING ANALYSIS. 2.935	7E+06
C:\User	s\Public\Documents\Al	RMD60\Project\THRSBR-Pr	C:\Users\Public\Documents\ARMD60\Project\]	THRSBR-Pre	Bearing Performance Including Pressure Distribution @ 1500 RPM	2E+06
GEARBOX	Fluid-Film THRUST BEARING AN	NALYSIS.	14 PAD SHROUDED TAPERED LAND.	15000 0 00		7E+06
Bearing Per	formance Including Pressure Distr	ribution @ 15000 RPM.	Pad 1 of 14 Circumferential Direction	15000 KPML		00,00
Number of	Pads		1 (Pad Angle = 20.0 degrees)	41		3E+06
14 Red Ande	4	5 4 2				8E+06
20.0	degrees				1 6512	3E+06
Orientation	Angle, degrees	2 1 2 2			1.4679	9E+06
0.0	7	S MARY S II			1.2844	4E+06
Outer Radiu	us, mm 🖌		<u>5</u>			9E+06
DU.U	ie mm		5		9.174	1E+05
35.0	8	Orientation Angl			у 🏹 7.339	3E+05
Axial Cleara	ance, mm				L 1_X 5.5045	5E+05
0.125 Second DD	. 9				3.669	6E+05
15000.0	141				Contours Pressure [Pascal (Newton/m*2)] Deformation Pressure [Pascal (Newton/m*2)] 1.8346	8E+05
Groove Ang	gle, degrees	<sup>1</sup> 11 <sup>12</sup>			College Clearance Set 1 0.0250 0.0000	02+00
5.714286		·	rad gild model		C:\Users\Public\Documents\AKIVID0\Inrsbr\tnrpost.tnv	
					THRSRR-Project01	





- 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.

#### > 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 6 to 8 will automatically modify the graphics model as shown below.



Modifying pad grid network size from 31 X 41 to 23 X 31 (shown below for axially symmetric grid) displays new grid model, including its feature of shrouded tapered land configuration added to the specified grid size.



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

RBTS, Inc., 1041 West Bridge Street, Phoenixville, PA 19460, USA • Tel:610-415-0412 • info@rbts.com • www.rbts.com Page 15 of 21

Post-Processor. Following a complete bearing modeling and performance map solution as a function of axial clearance/gap, the post processor illustrated below immediately provides 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 Clearance or Load, Speed, Viscosity, Flow Rate, Temperatures, Pressure, Chamfers geometry, etc.

	Thrsbr (C:\Users\Public\Documents\ARMD62\THRSBR\GEARBOX-Tapered-Land.THI US) - 🗆 🗙
	File Edit Bearing Options Advanced   Run Analysis   Post-Processor   View Tools Window Project Help
	🎦 New 💕 Open 🚼 Save   🐰 Cut 🖺 Copy 🖺 Paste   🔯 Bearing Model 🎟 Pad Grid Model   Insert Value:
	Post-Processor
Modeled Bearing	Description GEARBOX Fluid-Film THRUST BEARING ANALYSIS. 14 PAD SHROUDED TAPERED LAND Pressure Distribution @ 15000 RPM.
Geometry	R-Outer         1.906         R-Inner         1.375         Number of Pads         14           Pad Angle         20.0         Orientation Angle         0.0         No. of Clearances         49           Min Clearance         5.000000e-05         Rotational Speed         15100.0         Viscosity         1.30000e-06
User Specified Case(s) &	Single Case       Multiple Cases       Lubricant Properties         Image: A structure       Image: A structure <td< td=""></td<>
Operating Conditions	Solve For     Load       Clearance     0.0025       Speed     15100.0       Load     0.0
	Single Case results are displayed here after the Run button is pressed.
	Ok     Cancel     Help
	No project open

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 / use.

				<u></u>	Lubricant Library						×			
	Lubricant Properties					➡ Insert	💠 App	bend	X Delete	E Duplicate				
		Supplier	Typical		Supplier	BrandName	ISO Grade	API Gravity	1st Kinematic Viscosity Point	1st Kinematic Viscosity Temp.	2nd Kinematic Viscosity Point	2nd Kinematic Viscosity Temp.	^	
r	•	Dened News	ISO Gende 22.04		TEXACO	REGAL R&O 220	220	26.7	220.0	104.0	18.1	212.0		
	Choose Lubricant	brand Name	ISO Grade S2 OI		TEXACO	REGAL R&O 320	320	26.1	320.0	104.0	23.1	212.0		
l	<u> </u>	ISO Grade	32		TEXACO	REGAL R&O 460	460	25.0	460.0	104.0	29.1	212.0		
		API Gravity	31.0		TEXACO	REGAL R&O N-100	100	22.0	100.0	104.0	9.0	212.0		
- Kinematic Viecoei	ties (for internolation)				TEXACO	REGAL R&O N-68	68	22.9	67.0	104.0	7.2	212.0		
1at Datiat	22.0	1	Tananahan	104.0	TOTAL	PRESLIA 100	100	28.206	99.3	104.0	11.4	212.0		
ist Point	32.0	ISt	Temperature	104.0	TOTAL	PRESLIA 32	32	31.144	32.3	104.0	5.4	212.0		
2nd Point	5 36	2nd	Temperatura	212.0	TOTAL	PRESLIA 46	46	30.214	46.3	104.0	6.8	212.0		
2101011	0.00	210	remperature	212.0	TOTAL	PRESLIA 68	68	28.568	67.4	104.0	8.7	212.0		
		Reset			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		
				9	8 Typical	ISO Grade 22 Oil	22	31.8	22.0	104.0	4.29	212.0		
				▶ 9	9 Typical	ISO Grade 32 Oil						212.0		
				10	0 Typical	ISO Grade 46 Oil	46	30.3	46.0	104.0	6.76	212.0	~	
				Supplier		Save	Sel	ect	Cancel	Help	]			
				· · · ·										

Lube / Chamfers / Feed-Nozzles: Both fixed geometry bearings oil grooves feeding-system and their geometrical chamfers as well as tilting pad bearings feed nozzles numbers and orifice geometry, may influence the bearing performance significantly. In the fixed geometry bearings the flow rate through the bearing is controlled by both the bearing internal clearances and groove's resistance to flow, while in the 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 impacts 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 either a pressurized grooved feeding system, pressurized nozzle feeding system, or classical flow assumption (flooded environment). By default, classical flow is simulated by assuming that the bearing's supply flow rate is equal to its side leakage flow rate (non-starved lubrication).

When the flow type is set to "**Grooved**" shown below, the supply pressure and groove details (including chamfer type and dimensions) are to be specified by the user. Depending on the chamfer type selected (triangular, rectangular and circular), the required data will be displayed as illustrated.

👌 Single Case Lube Details					
Lubricant Conditions			<u>Thrust Bearing</u>	Y	
Solve For Film Temp -	User Specified Viscosity an	nd Heat Content		T	
Film Temperature 160.0	Viscosity / Heat Content			<u>Cham</u>	<u>fer Geometries</u>
Supply Temperature 120.0	Viscosity	0.0		T ▲ ◎ > Nor	ne – No Chamfer
Flow Type Grooved -	Heat Content	0.0	$\leq$		ngular
Supply Flow Rate 3.0					xtangular Sular
Feeding System					
Fixed Geometry Pads				- Direction	of Rotation
Groove Feeding System	1				
Chamfer Denth 0.125	Supply Pressure	20.0			~ <u>^</u>
Chamfer Angle 90.0	Orifice Diameter	0.075	<u>Iriangular</u>	<u>Rectangular</u>	<u>Circular</u>
Groove Length 0.4			5 🔨	5	S Readius
			Angle	Width	+
Ok	ancel Help				
Lube Supply Temperature	۴		Depth	Sopur	Depth
	Tringerdan M		1		
		Fixed Geometry Pads Groove Feeding Sv.	stem		
Grooved 🗸	Triangular	Chamfer Type	Triangular V		
Classical	Circular Rectangular	Chamfer Depth	3.0	Supply Pressure 1500 Orifice Diameter	10.0
Non-Grooved	nootangalar	Groove Length	10.0		
					_
Fixed Geometry Pads		Fixed Geometry Pads	7		
Groove Feeding System		Groove Feeding Sys	stem		
Chamfer Type Rectangular ✓ Chamfer Depth 4.0 Supply Pre	ssure 150000.0	Chamfer Type     Chamfer Depth	Circular V 3.0	Supply Pressure 1500	100.0
Chamfer Width 4.0 Onfice Dia	neter 10.0	Chamfer Radius	45.0	Orifice Diameter	10.0
Groove Length 10.0		Groove Length	10.0		
	_				-

For flow type is set to "**Non-Grooved**" shown below, pressurized lubricant is supplied through sharp-edge orifices or 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.

Lubricant Conditions			
Solve For	Film Temp 🔹	User Specified Vis	scosity and Heat Conten
Film Temperature	0.0	Viscosity / Heat Content	
Supply Temperature	50.0	Viscosity	0.0
Flow Type	Non-Grooved 💌	Heat Content	0.0
Supply Flow Rate	5.0		
Feeding System Non - Grooved	System	]	
Feeding System Non - Grooved Non - Grooved Feeding S	System	]	
Feeding System Non - Grooved Non - Grooved Feeding S # of Orifices per Pad	Bystem 1	Supply Pressure	150000.0
Feeding System Non - Grooved Non - Grooved Feeding S # of Orflices per Pad Orflice Discharge Coeff.	Dystem 1	Supply Pressure Onfice Diameter	150000.0
Feeding System       Non - Grooved       Non - Grooved Feeding S       # of Orflices per Pad       Orflice Discharge Coeff.	System 1	Supply Pressure Onfice Diameter	150000.0 10.0

Illustration of Three Feed Orifices/Nozzles per Pad



**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.

Description       Pressure/ (EEARB0X Fluid-lim THRUST BEARING ANLYSIS. 14 AD SHROUDED TAPERED LAND Bearing Performance Including Pressure Distribution @ 15000 RPM.       Clearance Distributions 3D View Button 3D View Button 4 9 Angle 500000e-05 Retational Speed 15100.0 Viscosity 1.300000e-06 Run Analysis 50 View Button 4 9 Angle 50 Cearance Clearance 0.005 Speed 15100.0 Load 2200.0 Performance Results including bearing system heat balance and supply pressure considerations       Pressure 19.992 (Deg.F) 50.992 (Deg.F) 50.992 (Deg.F) 50.992 (Deg.F) 50.992 (Deg.F) 50.992 (Deg.F) 50.994 (Deg.F) 70.0024 (Degm) 70.0024 (	bearing system.	Post-Processor	- • ×
Modeled Bearing Details       R-Outer       1.306       R-Inner       1.375       Number of Pads       14         Pad Angle       20.0       Orientation Angle       0.0       No. of Clearances       49         Min Clearance       5.000000e-05       Rotational Speed       15100.0       Viscosity       1.300000e-06         Scroll through cases.       Single Case       Multiple Cases       Lubricant Properties       Analysis         Operating Conditions       Solve For       Clearance       Question       Question       2200.0         Operating Conditions       Solve For       Clearance       Question       Question       2200.0         Operating Conditions       Solve For       Clearance       Question       Question       2200.0         Operating Conditions       Solve For       Clearance       Question       Power-Loss		Description GEARBOX Fluid-Film THRUST BEARING ANALYSIS. 14 PAD SHROUDED TAPERED LAND Bearing Performance Including Pressure Distribution @ 15000 RPM. 31	Pressure/ Clearance Distributions D View Button
Scroll through cases.       Single Case       Multiple Cases       Lubicant Properties       Analysis         Operating Conditions       Solve For       Lube/Chamfer       Run       3D         Operating Conditions       Solve For       Clearance       Clearance <td>Modeled Bearing Details_</td> <td>R-Outer         1.906         R-Inner         1.375         Number of Pads           Pad Angle         20.0         Orientation Angle         0.0         No. of Clearances           Min Clearance         5.000000e-05         Rotational Speed         15100.0         Viscosity</td> <td>14 3 49 1.300000e-06</td>	Modeled Bearing Details_	R-Outer         1.906         R-Inner         1.375         Number of Pads           Pad Angle         20.0         Orientation Angle         0.0         No. of Clearances           Min Clearance         5.000000e-05         Rotational Speed         15100.0         Viscosity	14 3 49 1.300000e-06
Complete Bearing Performance Results including bearing system heat balance and supply pressure considerations.       Operating C> Operating C Operating C Operating C Operating C Operating C Operating C	Scroll through cases.	Single Case     Multiple Cases     Lubricant Properties     Run       Image: Analysis     Image: Analysis     Image: Analysis	3D
	<b>Complete Bearing</b> <b>Performance Results</b> including bearing system heat balance and supply pressure considerations.	Operating Conditions         Solve For         Clearance           Operating C>         0.0005         Speed         15100.0         Load           Operating C>         0.000557         (Inch)         Min.Film Thick>         0.000557         (Inch)           Load Capacity>         2.200E+03         (Lbf)         Power-Loss>         7.202E+00         (Power-Loss>         7.202E+00         (Power-Loss>         7.202E+00         (Cearance upower-Loss>         7.202E+00         (Power-Loss>         1.423E-01         (Comer-Loss>         1.423E-01         (Power-Loss>         (Power-Loss>         Power-Loss>         7.202E+00         (Power-Loss>         (Power-Loss>	2200.0 (nch) ^ ipm) ipm) ipm) ipm) ipm) ipm) 2   )6 )2   Im

**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, Chamfers geometry, etc.

Parame	etric		•					Post	t-Proo	cessor					-		×
bearing performance is accomplished efficiently																	
	itiy.		R-Outer Pad Angle Min Clearance 0.				50.0     R-Inner     35.       20.0     Orientation Angle     0.       .00125     Rotational Speed     15000.					0.0 Number of Pads 0.0 No. of Clearances 0.0 Viscosity			14 50 6.894758e-03		14 50 -03
Expand butto	n if		Sing		Expand	1	Lubricant	Properti	es					[	4	Run	
pressed will expand the window to the full width of the parent window which provides a quick view of all the columns		he   h k s			Clearan	ce	Speed		Load		Use Lube Viscosity / Heat Content	Specified Viscosity		Specified Heat Content		Tem	F F
for efficient da	ata entry		Þ	1	(	0.025	]	1000.0		0.0			0.0		0.0		_
				3	(	).025 ).025	4	4000.0		0.0			0.0		0.0		-
Restore			Use														🖋 Run
Clearance	Speed Lo	oad Vi / C	iscosity / Heat Content	Specified Viscosity	Specified Heat Content	Film Temperatu	re Temperat	ture Flor	w Rate	Flow Type	Chamfer Type	Supply Pressure	Orifice Diameter	Groove Length (Grooved)	Chamte (Groo	r Depth oved)	(Grooved)
1 0.025 2 0.025	1000.0 2000.0	0.0		0.0	0.0		0.0	50.0 50.0	5.0	Grooved V Grooved V	Triangular V	100000.0		3.0 10.0 3.0 10.0		1.25	90.0
4 0.025	6000.0	0.0		0.0	0.0		0.0	50.0	5.0	Grooved V	Triangular V	100000.0		3.0 10.0		1.25	90.0
5 0.025 6 0.025	8000.0 10000.0	0.0		0.0	0.0		0.0	50.0 50.0	5.0 5.0	Grooved V Grooved V	Triangular V Triangular V	100000.0		3.0 10.0 3.0 10.0		1.25 1.25	90.0 90.0
7 0.025 8 0.025	12000.0 14000.0	0.0		0.0	0.0		0.0	50.0 50.0	5.0 5.0	Grooved V Grooved V	Triangular V	100000.0		3.0 10.0 3.0 10.0		1.25 1.25	90.0 90.0
▶ 9 0.025	15000.0	0.0		0.0	0.0		0.0	50.0	5.0	Grooved ✓	Triangular ∨	100000.0		3.0 10.0		1.25	90.0
11 0.025	18000.0	0.0		0.0	0.0		0.0	50.0	5.0	Grooved ¥	Triangular Y	100000.0		3.0 10.0		1.25	90.0
Multiple cas below. The "Bearing Perfor	e bearing ARMD g	g perf graphi	form iCS l sure I	nance ro utility ca	esults ar an be us m @ 15000 R	ed to	omatic display	ally d y X-Y C:\Use	isplay plots rs\Public\l edLandShr	/ed in te of any Documents\ARM ouded14PadThm	ext forma of the go D60\Project\THR ustBearingSamp	at as illu enerate RSBR-Project01 Je01.rpg	ustrate d resi	ed ults.		1.20	30.0
No. (Deg-C) Lo	ad-NEWTON (	(Pascal)		(rpm)	(m/sec)	Max.1	Number	8	8						- Supp Film 1	y Tempera emperatur e Tempera	iture e ature
$ \begin{array}{ccccccc} 1 & 50 & 803 & 5 \\ 2 & 51 & 658 & 1 \\ 3 & 53 & 427 & 1 \\ 4 & 55 & 236 & 2 \\ 5 & 57 & 055 & 3 \\ 6 & 58 & 864 & 4 \\ 7 & 60 & 653 & 4 \\ 8 & 62 & 409 & 5 \\ 9 & 63 & 277 & 5 \\ 10 & 64 & 135 & 5 \\ 11 & 65 & 823 & 5 \\ 12 & 67 & 479 & 6 \\ \end{array} $	.376E+02 1 041E+03 3 .951E+03 6 .742E+03 6 .430E+03 1 .029E+03 1 .553E+03 1 .015E+03 1 .224E+03 1 .784E+03 1 .107E+03 1	1.725E+0 3.342E+0 6.263E+0 8.802E+0 1.101E+0 1.462E+0 1.610E+0 1.610E+0 1.740E+0 1.960E+0 1.960E+0	555566666666666666666666666666666666666	$\begin{array}{c} 1.000 \pm +03\\ 2.000 \pm +03\\ 4.000 \pm +03\\ 6.000 \pm +03\\ 8.000 \pm +03\\ 1.000 \pm +04\\ 1.200 \pm +04\\ 1.400 \pm +04\\ 1.400 \pm +04\\ 1.500 \pm +04\\ 1.500 \pm +04\\ 1.800 \pm +04\\ 2.000 \pm +04\\ \end{array}$	5.236E+00 1.047E+01 2.094E+01 3.142E+01 5.236E+01 6.283E+01 7.330E+01 7.330E+01 8.378E+01 9.425E+01 1.047E+02	1.88 3.89 8.33 1.33 2.55 3.20 4.30 4.30 4.75 5.66	37E+01 97E+01 19E+01 32E+02 93E+02 08E+02 08E+02 55E+02 59E+02 90E+02 33E+02 33E+02 45E+02	7 7 7 6 6 6	6 4 2 70 88 66 44 22			_	/		— Max.	Temperatu B	re D
Case Clearance M No. (mm)	inimum-C She (mm) Max	ear-Stre K.(Pasca	ess So (1) At	ommerfeld vg.Number	Power Loss (watt)	Max: Pres (Pas	imum ssure scal)	aboo 5	i0 i8			-					
1 2.500E-02 2 2 2.500E-02 2 3 2.500E-02 2 4 2.500E-02 2 5 2.500E-02 2 6 2.500E-02 2 6 2.500E-02 2 7 2.500E-02 2 9 2.500E-02 2 9 2.500E-02 2 10 2.500E-02 2 11 2.500E-02 2 12 2.500E-02 2 12 2.500E-02 2 12 2.500E-02 2	.500E-02 4 .500E-02 6 .500E-02 2 .500E-02 2 .500E-02 3 .500E-02 3 .500E-02 4 .500E-02 4 .500E-02 4 .500E-02 4	4.152E+0 8.043E+0 1.507E+0 2.118E+0 2.650E+0 3.112E+0 3.517E+0 3.873E+0 4.035E+0 4.035E+0 4.188E+0 4.468E+0 4.717E+0	3 3 4 4 4 4 4 4 4 4 4 4 4 4 4	3.093E+01 3.093E+01 3.093E+01 3.093E+01 3.093E+01 3.093E+01 3.093E+01 3.093E+01 3.093E+01 3.093E+01 3.093E+01 3.093E+01	3.832E+01 1.495E+02 5.564E+02 1.956E+03 2.872E+03 3.895E+03 5.005E+03 5.05E+03 5.187E+03 6.184E+03 7.422E+03 8.707E+03	4.55 8.85 1.65 2.99 3.45 4.42 4.42 4.55 5.1	51E+05 52E+06 52E+06 55E+06 55E+06 55E+06 52E+06 90E+06 90E+06 90E+06 •	5 5 5 4 4 4 4 4 4 4	4 0 8 6 4 2 0 0 0 0 0			1.000 Speed (PD	M) (F+04)		<u> </u>		2.000

Page **19** of **21** 



#### 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.		Workspace Configuration: Chart(1)	
The workspace	Graphs	Set Lines Details Line Defaults Annotations Line Markers	
configuration form consists of two panels. The left panel contains a tree	i Graph - Default i Charts L Chart - 1 i Output Files L (1) TaperedLand3Pads.psg SI	File Contents Units Speed (RPM)	Chart Type Une v X Axis Unit Speed (RPM) Speed (RPM)
graphs, charts, and graphic output files. The right panel contains all chart and graph settings.		Coerthicty     Att. Angle     Power-Loss     Shear-Stress     Sommefield Number     Reynolds Number     Max. Pressure     Supply Pressure     Supply Pressure     Supply Row     Excess Row     Supply Row     Exce	Units mm Line File Clearance (1) TaperedLand3Pad Eccentricity (1) TaperedLand3Pad
-	Save Workspace     Use Current Files       Open Workspace     Show/Update Graphs	Replace File	

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.
- 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.



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

> Telephone: Facsimile: Web: Email:

610-415-0412 610-415-0413 www.rbts.com info@rbts.com

# **ARMD**<sup>I</sup>- 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 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.



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:

**Dr.-Ing. Andreas Laschet · Apolloniaweg 6 · 51515 Kuerten · GERMANY** Phone: +49 2268 901650 · E-mail: info@laschet.com · Web: www.laschet.com



**RBTS**' software has gained international reputation for its:

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



# **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





# **Dr.-Ing. Andreas Laschet**

Engineering Service & Technical Consulting

Apolloniaweg 6 · 51515 Kuerten · GERMANY

Ph: +49 2268 901650 · E-mail: info@laschet.com · www.laschet.com