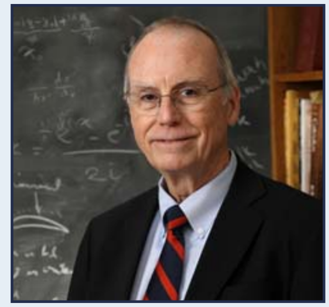
UVA

SCHOOL of ENGINEERING & APPLIED SCIENCE
Department of Mechanical and Aerospace Engineering
Rotating Machinery and Controls Laboratory

ROMAC NEWSLETTER

FALL 2020

From our Director


Houston Wood

No doubt we can all agree this has been a year that will not fade from memory for anyone having lived through these months of coping with COVID-19. It seems to me it will remain a serious and fluid situation for the unforeseeable future.

I can report the we have barely missed a beat since the University ordered labs and the building to be shut down, strict guidelines to be followed to gain access, and the need for following social distancing and the use of face coverings.

Throughout spring and summer semesters our graduate students and some undergraduate students continued their research. All faculty and staff continued to work remotely, and meetings were held via Zoom. We were also able to produce the 2020 ROMAC Annual Meeting for on-line viewing and participation. To do so we had to overcome several obstacles regarding the restrictions the School of Engineering had put in place. The meeting was a bit delayed, and available for interactive viewing for two weeks in August. It remains accessible to ROMAC members.

We have reserved the OMNI Charlottesville Hotel for June 21 – 25, 2021, for the 2021 ROMAC Annual Meeting. We are hopeful that we will be meeting in person, however, we are aware of the possibility we may again be presenting the annual meeting on-line. Additional details and information will be forthcoming via email, and the website.

We hope you and yours are well and remain so as we continue to adjust and navigate these ever changing times.

Houston

Houston Wood, Professor
Mechanical & Aerospace Engineering
Director, Rotating Machinery & Controls Consortium & Laboratory

SPECIAL POINTS OF INTEREST

University of Virginia
Mechanical & Aerospace Engineering
is DRIVE-N

The past few months we have seen and become more aware of ongoing systemic and social issues coming to the forefront of our daily life. The department of Mechanical & Aerospace Engineering (MAE) has stepped forward to create, establish, and commit to a newly formed structure for diversity and inclusivity within all aspects of education and operation of the department.

Under the guidance of department chair, Eric Loth, our attention is on making Foundational Changes to Improve Diversity and Inclusion. A number of task forces comprised of faculty, staff, graduate and undergraduate students and alumni have formed with the goal of improving the foundation of MAE. Each taskforce has identified areas in need of transformation, set goals and have developed action plans to focus on Diversity, Respect, Inclusion, Vision and Equity (DRIVE) Now to make a meaningful difference in the lives of all who pass through the Mechanical & Aerospace Engineering Dept.

New Student: William Arcand seeks MAE M.S. Degree

Will entered UVA as a graduate student and joined the ROMAC Lab in August 2020. He graduated from Massachusetts Institute of Technology in 2018 with a B.S. degree in Mechanical Engineering and thereafter worked as a Mechanical Validation Engineer in the Automotive field prior to joining ROMAC. Will is interested in Controls Design and will be working with Prof. Roger Fittro, as well as other ROMAC faculty on developing a Magnetic Bearing testing rig.

Visiting Scholar: Ke Zhifang aka Linus Kirt

Linus Kirt is a Ph.D. candidate from the Beijing Institute of Technology in Beijing, China. His research interests are: blade load characteristics of blade surface, the design of 3D cascade system towards stamped blade based on Bezier surface and research on the blade reverse method of stamped 3D cascade system. Linus presented a talk on his research at the 2020 ROMAC Annual Meeting entitled: Study on the Dynamic Wedging Characteristics of One-way Clutch Under Transient Loads from Stator. His visiting appointment is through mid-July 2021.

Graduating MAE MS Student to Join ROMAC

Zihao Huang will complete his M.E Degree this semester. His current research is in fluid journal bearings. He will join the ROMAC Lab in pursuit of a Ph.D. degree working with Chris Goyne and Cori Watson-Kassa.

ROMAC Members Retire

We are grateful to their service to the ROMAC Consortium and send our best wishes as they begin the next chapter of their journey.

Jack Cofer, Simulia Dassault

Jack retired from Simulia—Dassault Systemse in August of this year. Jack was the SIMULIA User Experience Solutions Manager and an active member of the ROMAC Consortium. Jack was a regular attendee at annual meetings and a proud UVA alumni. He often gave presentations to the ROMAC membership at the annual meetings, and enjoyed the opportunity to return to Charlottesville.

John Kocur, Exxon Mobil

John is a UVA and ROMAC alum, recently retired from Exxon Mobil, after a long career working with various ROMAC members, ending with 18 years at XOM. John was very actively involved with the ROMAC Consortium and has been an involved contributor to the development of RotorLab.

Albert Schmitz—RENK Hanover

Albert was the RENK AG-Werk Hanover ROMAC representative since 2007. Many annual meetings have been attended by Albert and his RENK colleagues.

2021 ROMAC Annual Meeting

June 21—25, 2021

OMNI Charlottesville Hotel

We hope to welcome you to Charlottesville for the 2021 Annual Meeting and we are preparing to do just that, however, we are committed to monitor the on going COVID-19 pandemic. Decisions will be made in early spring.

OMNI Charlottesville Atrium

Conference Room set-up

The Rotunda

Charlottesville Downtown Mall

A view of the Blue Ridge Mountains

2021 ROMAC Consortium Membership Fees

Due March 31, 2021

Invoices went out in October

2021 ROMAC Membership Fees

Standard Membership
- Initiation Fee: $28,500
- Annual Membership Fee: $30,000
- $28,500 if payment is received on time (by 3/31/2020)
- Two (2) Company representatives may attend the ROMAC Annual Meeting at no cost.
- Additional attendees may participate for nominal fee
- Company representative is eligible to serve on the ROMAC Advisory Board

*Small & Medium-sized Enterprise (SME) Membership (< 250 employees)
- Initiation Fee: $10,000
- Annual Membership Fee: $21,000
- $20,000 if payment is received on time (by 3/31/2020)
- One (1) Company representatives may attend the ROMAC Annual Meeting at no cost
- Additional attendees may participate for a nominal fee
- Eligible to serve on the ROMAC Advisory Board
- Proportional Research Project Voting

*Small Business Membership (< 50 employees)
- Initiation Fee: $5,000
- Membership Fee: $14,250
- $13,500 if payment is received on time (by 3/31/2020)
- One (1) Company representative may attend the ROMAC Annual Meeting at no cost
- Additional attendees may participate for a nominal fee
- Not eligible for membership on the ROMAC Advisory Board
- Proportional Research Project Voting

Academic Educational Membership
- Membership Fee: $2,500/semester
- Access and use of RotorLab+ software for Educational purposes
- Representatives may attend the ROMAC Annual Meeting for a nominal fee
- Not eligible for membership on the ROMAC Advisory Board or in Research Project Voting

If you would like additional information regarding membership under these guidelines contact us:

(434) 924-3292 | romac@virginia.edu | ROMAC Website

Graduate Student Research Projects

Trade-offs between emissions, cost and resilience in load-balancing technologies supporting deep deployment of intermittent renewable generation

Student: Jeff Bennett
Expected Degree: Civil Engineering, Ph.D., 2021

Wind and solar power are currently the least expensive forms of new power generation in many parts of the world. Their variable nature, however, requires technical innovation before the electric grid can operate with high levels of deployment. In addition to reduced electricity costs, high deployment of solar and wind power is necessary to limit climate change. The two primary approaches for load-balancing intermittent renewables are fast-acting power plants and energy storage. Existing power plants cannot change power output at a rate suitable for load-balancing, and battery-based energy storage is not currently affordable at the grid scale.

Previously, my research focused on supercritical carbon dioxide power plants and distributed electric grid architectures. During this past year, my research has expanded to include Offshore Compressed Air Energy Storage (OCAES). OCAES is a novel energy storage technology in which compressed air is stored in offshore saline aquifers when excess power is available and later extracted and used to drive a turbine when power is needed (Figure 1). Offshore wind farms planned in the Mid-Atlantic overlap several saline aquifers, so we analyzed the potential of co-locating OCAES with a wind farm to reduce system costs. Water injection is used during compression and expansion to achieve near-isothermal processes resulting in high round trip efficiencies without the use of fossil fuels. This research included a technoeconomic assessment of OCAES with a process model to assess the round-trip efficiency and storage potential by simulating the fundamental physics relationships. Round trip efficiencies up to 80% are estimated but results are sensitive to subsurface parameters, particularly permeability. Capital costs for OCAES are projected to be lower than current estimates for lithium ion batteries. The value of OCAES to the electric grid was evaluated by optimizing its operation over a year of wind generation and spot market price data in the Mid-Atlantic. It was found that OCAES increases the revenue of the wind farm by shifting when wind energy is sold to the electric grid.

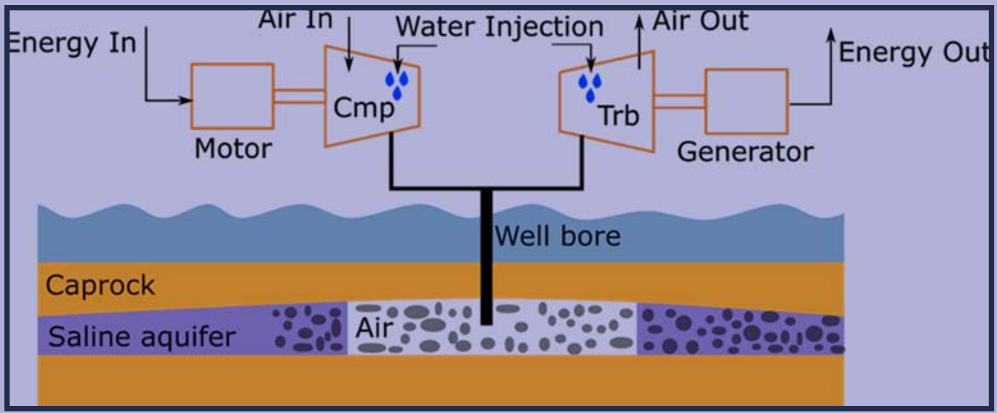


Figure 1: Overview of an offshore compressed air energy storage (OCAES) system that combines a near-isothermal compressor (Cmp) and turbine (Trb) with a saline aquifer for air storage.

CFD Model Simplification Strategies for Annular Seals

Student: Neal Morgan
Expected Degree: MAE Ph.D. 2020

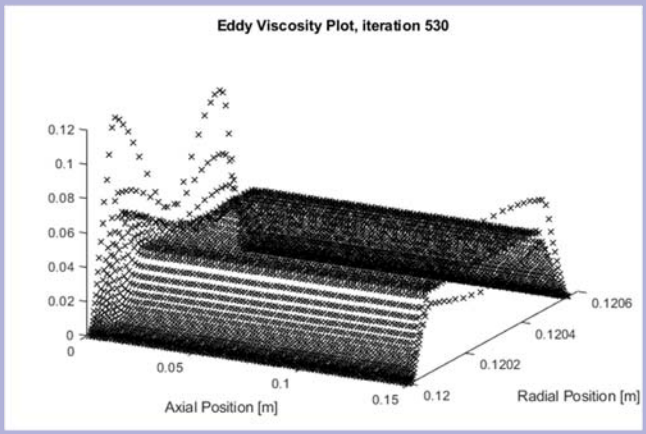
Annular pressure seals are critical components used in turbomachinery. The annular seal is a thin annular clearance region "sealing" between a high-pressure region and a low-pressure region of a rotating machine by limiting the leakage of the working fluid. The working fluid leakage is limited by the cross-sectional area allowed to the flow, and frequently further limited by axisymmetric grooves machined into the rotor or stator within which the fluid expands, contracts, and recirculates. Modern analysis techniques of such seals tend to fall into two categories. Either the seal model is greatly simplified through assumptions and application of empirical factors, or the seal is modeled using 3-D CFD techniques in generalized fluid dynamics codes. The method of simplification is referred to as "Bulk Flow" analysis due to the use of radially averaged "bulk" values for flow variables. This model takes those radially averaged values and assumes a circumferential solution based on small orbit circular whirling motion. The 3-D momentum equations are thus reduced to a series of 1-D equations in the axial direction with shear forces modeled empirically through Blasius type friction factors. These 1-D equations can be solved rapidly at the expense of accuracy and flexibility in seal geometry types. Comparatively, 3-D CFD codes require large 3-D meshes and the solution of the full 3-D Navier-Stokes equations accompanied by turbulence model. The CFD solutions are accurate within the precision of the boundary conditions used at the expense of much greater computational cost and engineer expertise requirements.

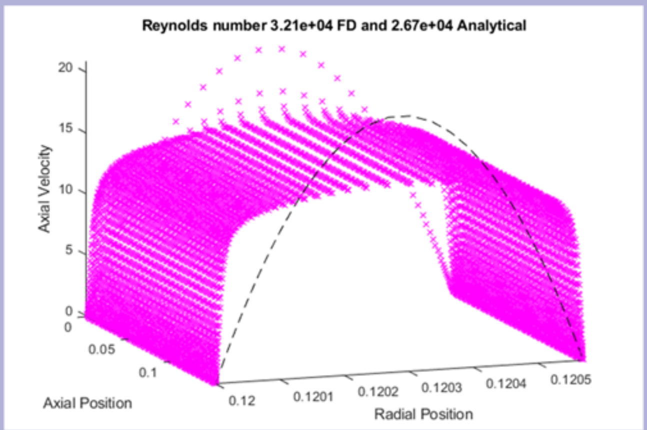
This work demonstrates methods of reducing the complexity of annular pressure seal modeling with minimal losses to solution accuracy. A 2-D seal code is under development with an axial-radial grid to strike a balance between the 1-D bulk flow method and 3-D generalized CFD. This 2-D seal code distinguishes itself through rigorous application of modern numerical and code techniques. The code allows the 0^{th} and 1^{st} order solution of the geometrically perturbed and incompressible cylindrical Reynolds Averaged Navier-Stokes equations to model the seal's eccentric annular region with an assumed small and circular whirl orbit. Currently a single one-equation turbulence model is included to model the transport of turbulent kinetic energy for high Reynolds number flows. The 0^{th} order solution provides the user with leakage results, wall shear stress, and initial pressure differential estimates. The 1^{st} order solution refines the pressure differential estimate and models the circumferential variation to obtain rotordynamic coefficients from multiple whirl speed cases.

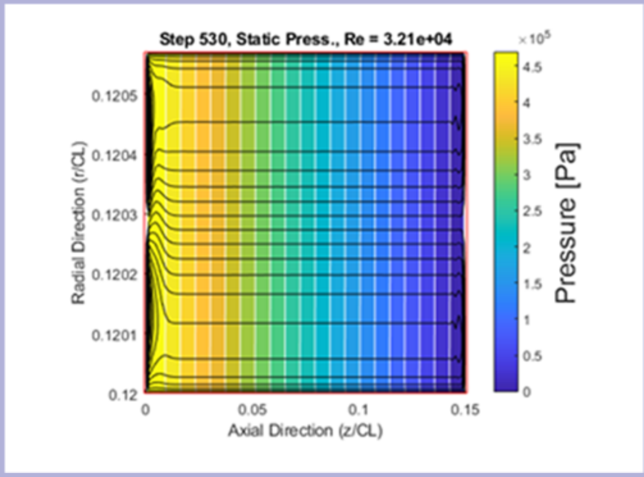
Figures related to this research report appear on the following page.

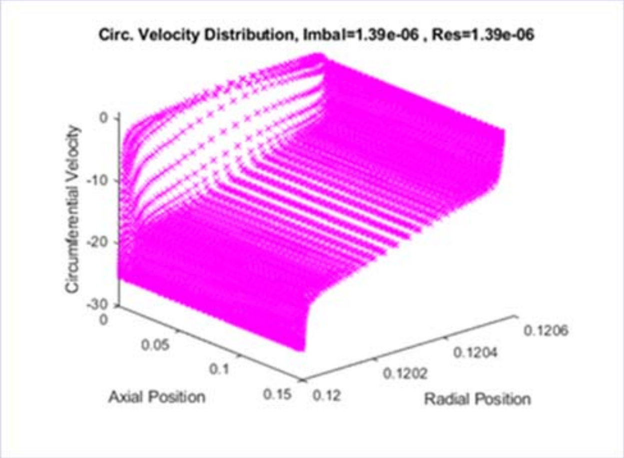
CFD Model Simplification Strategies for Annular Seals *(con't)*

The current state of the 2-D seal code consists of laminar solutions for zeroth and first order perturbation results and zeroth order solutions with the Prandtl one-equation turbulence model included. The zeroth order turbulence model solution is in debugging and validation testing, leading up to the inclusion of turbulence in the first order solution results as well. Future efforts beyond the completion of the dissertation will likely focus on expanding the seal geometry handling of the code.







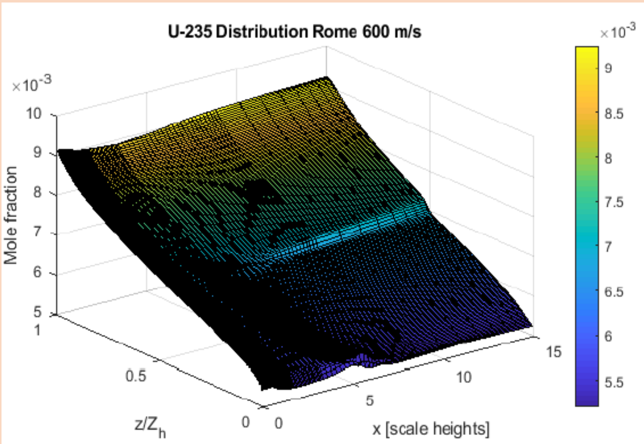


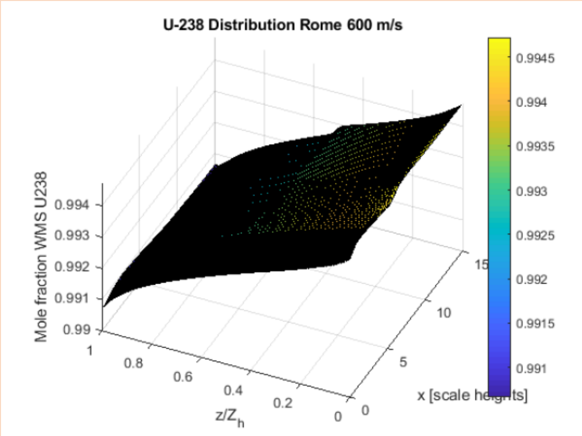
Two-Dimensional Multi-Isotope Separation in a Gas Centrifuge Using Finite Element Analysis

Student: Wisher Paudel
Expected Degree: Mechanical Engineering, PhD., December 2021

A finite element model of a gas centrifuge is developed to compute the optimal two-dimensional multi-isotope separation. The mass flow field generated using Onsager's equation without the pancake approximation is used as an input to the diffusion equation for each uranium isotope in the initial form of partial differential equations (PDE). The PDEs are reduced to their weak forms and the resulting integrals evaluated using gauss quadrature. The systems of equations are solved using an optimization routine to satisfy the overall mass and concentration balance inside the machine. The solutions obtained provide a holistic view of isotopic diffusion inside the centrifuge and the ability to quantify the molecular fraction of various uranium isotopes at a given radial and axial location at any desired initial and operating conditions. While several authors in the past [1] have solved the multi-isotope diffusion problems using 1-D approximations, there are no known 2-D finite element models in literature. The findings of this work, therefore, are not only be significant for the applications of nuclear non-proliferation but also a great analytic tool for nuclear scientific community.

The output of the newly developed code was tested using the parameters for two hypothetical gas centrifuges. The physical and operating parameters of the Rome and Iguaçu centrifuges used in the study can be found widely in open literature. The distribution of the U-235 and U-238 isotopes inside the Rome machine with radius of 0.25 m and axial length of 5 m for a feed rate of 25 mgUF6/s has been included below. The concentration at the feed is that of natural uranium. The x-axis is the radial direction non-dimensionalized into scale heights from x=0 at the wall to x=15 near the axis of rotation. The y-axis shows the non-dimensional axial length from y=0 at the bottom and y=1 at the top of the machine. The z-axis shows the mole fraction of the isotope at all the axial and radial locations in the centrifuge rotor. There is higher fraction of U-235 isotope at the top and towards the axis while there is higher concentration of U-238 isotope at the bottom, which indicates separation of the heavier and lighter uranium isotopes.





Active Magnetic Bearing Test Rig

Student: William Arcand
Expected Degree: MAE M.S. 2022

Active Magnetic Bearings (AMBs) enable high-speed, noncontact rotor operation. Additionally, the rotational dynamics can be actively controlled and optimized allowing for active vibration control. The potential for development and use of this technology related to industrial high-speed spindles and overhung test rigs is being explored. In this project, magnetic bearings and associated control designs will be implemented on a vertical shaft spin test rig in order to demonstrate overall system performance capabilities and demonstrate the accuracy of model predictions with actual test rig operating characteristics.

A design concept and system model have been developed from first principles to emulate existing spin test rigs which operate above their second bending critical frequency. Hardware components have been sourced to meet project requirements, and as seen in Figure 1, the design consists of and overhung rotor design with two radial AMB's, a thrust AMB, and a third AMB which will be used as a system exciter.

Work is presently underway associated with component and subsystem testing and validation: Motor/Motor Drive, Amplifier/Actuator, Sensing system, etc. In parallel, control design and algorithm development and hardware implementation are also in progress. Once these activities and full hardware system assembly is complete, the test rig will be commissioned and the performance of the various AMB control algorithms will be validated through operational testing and system characterization.

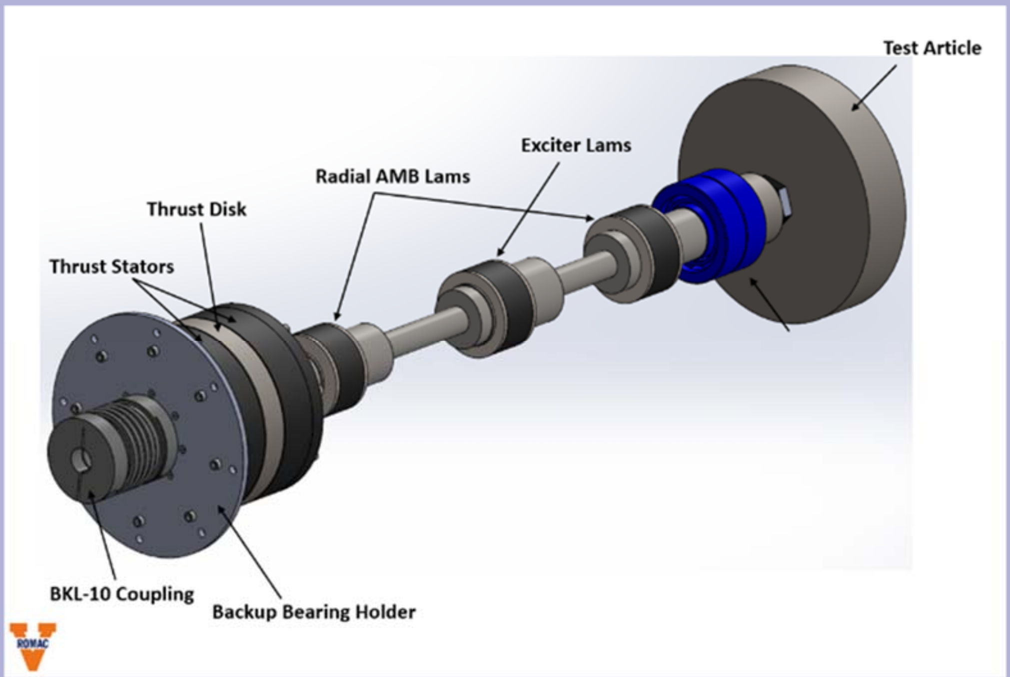


Figure 1: Rotor System Model

Study of Turbulent Prandtl number in Thrust Bearings

Student: Xin Deng
Expected Degree: Mechanical Engineering Ph.D. 2021

In order to capture turbulence related thermal effects in thrust bearings, the effect of turbulence on effective thermal conductivity needs to be quantified. This is typically achieved using a turbulent Prandtl number, which is the ratio between the turbulent eddy ratio and the thermal eddy viscosity.

The manner in which the turbulent Prandtl number varies across a channel has not been determined beyond doubt. Researcher in 1970s used an empirical value for the turbulence Prandtl number. The bearing industry has been using the empirical value since after. However, as intuitive knowledge, the turbulence Prandtl number should not be a fixed value.

Most researchers agree that the magnitude of the turbulent Prandtl number varies, in all probability, with both the molecular Prandtl number and the Reynolds number. It attains its largest value at the wall and decreases outward. More recent researchers also tried using CFD method to study the turbulence Prandtl number.

This study aims to study the turbulence Prandtl number and to model it in the ThrustX. This combined with improved cross film eddy viscosity predictions available in ThrustX will allow the thermal contribution of turbulence transition—where the peak temperature drops at transitional turbulence operating conditions—to be modeled.

A Bulk Flow Method for Circumferentially Grooved Liquid Seals Using CFD-Derived Effective Film Thickness

Student: Nathaniel Gibbons
Expected Degree: MAE PhD 2023

This project continues towards the development of new ROMAC analysis codes for circumferentially grooved seals that leverage the efficiency and ease of use of bulk flow methods while improving prediction accuracy for rotordynamic coefficients. In the new method, an effective film thickness definition is employed to more closely match the physical flow profile and capture associated flow effects that have thus far been neglected in bulk flow analysis methods.

Recent work has focused on the development of a hybrid CFD-bulk flow method utilizing a predefined effective film thickness. In the current implementation, an axisymmetric CFD simulation can be used to obtain the necessary code inputs. The full seal film thickness profile can be extracted using streamlines starting from the seal inlet plane (see figure). Other standard code inputs include the inlet loss and outlet recovery coefficients and inlet preswirl ratio which can all be readily obtained from the same axisymmetric CFD model. Ongoing work seeks to validate the current implementation of the hybrid method against existing experimental data, leading to the deployment of an effective film thickness hybrid CFD-bulk flow code. This year's focus includes a comparison between film thickness definitions when used in the current code, specifically between the new effective film thickness and the penetration angle definition used frequently in the literature, for an assessment of the accuracy improvements under the new definition. Future work will use a combined CFD and experimental approach to model the effective film thickness as a function of geometry and operating conditions, ultimately leading to new standalone bulk flow codes for circumferentially grooved seals based on the effective film thickness model and theory.

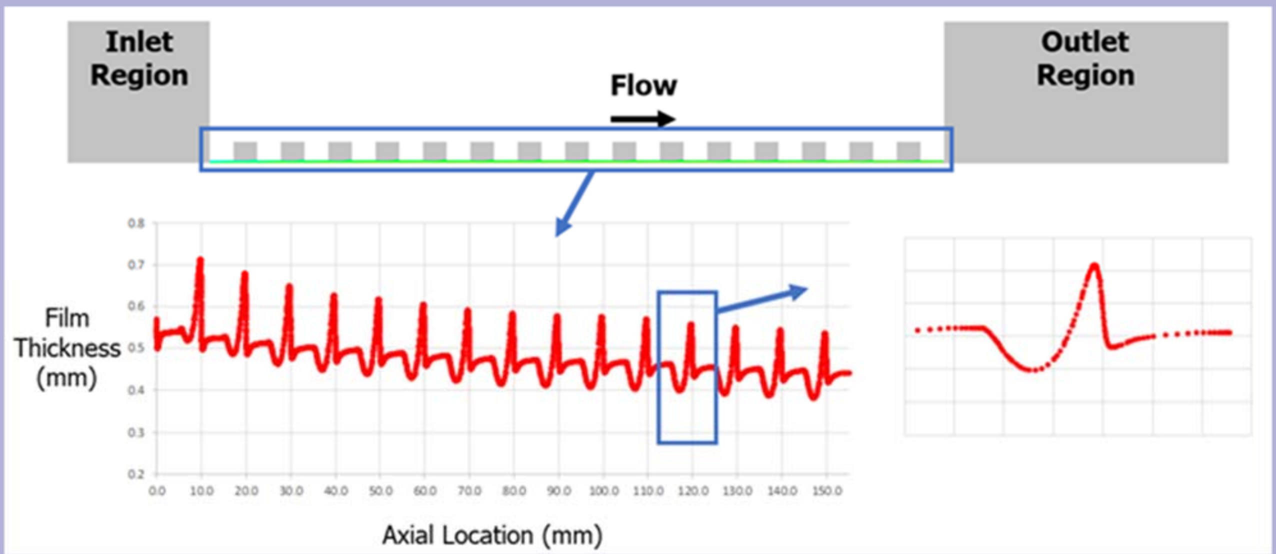


Figure 1: Example film thickness extraction for a circumferentially grooved seal. Top: sample seal geometry (axial-radial cross section) with film streamlines. Bottom left: extracted film thickness profile for entire seal. Bottom right: magnified film thickness profile for single seal groove.

Fluid Film Bearing Test Rig

Student: Pedro Herrera
Expected Degree: Mechanical & Aerospace Engineering Ph.D. 2023

The objective of the Fluid Film Bearing Test Rig Project is to build a test rig to experimentally determine the dynamic coefficients (stiffness and damping) of a fluid film bearing with an acceptable (approximately: <20% up to 500 Hz) coefficient uncertainty level.

Based on the preliminary design and analysis performed by Benstone Schwartz, the work has been continuing on in the following areas: developing component and subsystem specifications and detailed designs/drawings, identifying/communicating with part/component suppliers, building costs and a complete bill of materials, and defining/checking final technical details. This work is the basis to successfully develop the future purchasing and part manufacturing processes.

In addition to the baseline design (refer to the Figure below), a slight variation of the test rig design was considered and analyzed, which would eliminate the need for the use of a gearbox in the drive system. A high-speed electric motor would eliminate the need for a gearbox and simplify the lubrication system requirements, significantly reduce the required facilities related work as well as potentially reduce the total test rig costs and commissioning time. Performance and cost-related analyses for this alternative has been considered and was presented during this year's annual meeting, with the ultimate determination that the high-speed electric motor option's costs and system simplifications were not significant enough to justify a change to the overall system design at this late stage in the design process.

The following work continues in preparation of component manufacturing, purchasing, and assembly: finalizing the detailed designs for the test bearing, bearing housing, test shaft, magnetic bearings and shaft couplings. Final detailed specification of the sensing and Data Acquisition system, lubrication system specification and acquisition and commissioning requirements related to existing equipment in preparation for system assembly and start-up tests.

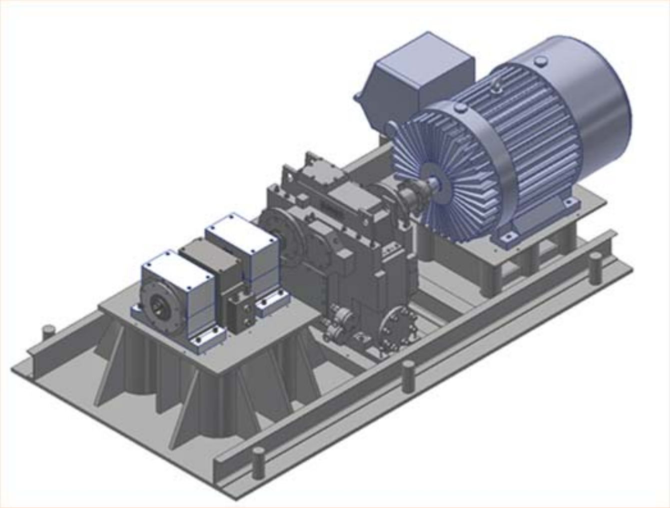


Figure: Existing design for the fluid-film bearing test rig (2019)

The Dynamic Wedging and Friction Characteristics of One-Way Clutch Under Transient Loads from Stator

Visiting Scholar: Ke Zhifang *aka* Linus Kirt
Expected Degree: Beijing Institute of Technology
School of Mechanical Engineering, Ph.D. 2021

This research focus on the one-way clutch and its wedging process in the torque converter. We take the torque fluctuation and its transient change due to the rotor-stator interaction and the switch of the conditions into consideration, therefore, the explicit dynamic model of one-way clutch with such transient and unsteady loads is set up and both the explicit dynamic method and statics structural method were used.

Comparing the former works whose loads come from the steady load, or those using the to evaluate the wedge process, the results by explicit dynamic with transient unsteady loads in this research would get more reasonable safety factor for design or optimization, also, the contact force results for the contact surface uncover more details of the wedge such as the collision or the roller's slide, and shows a dynamic mechanism for the self-lock mechanism for one-way clutch.

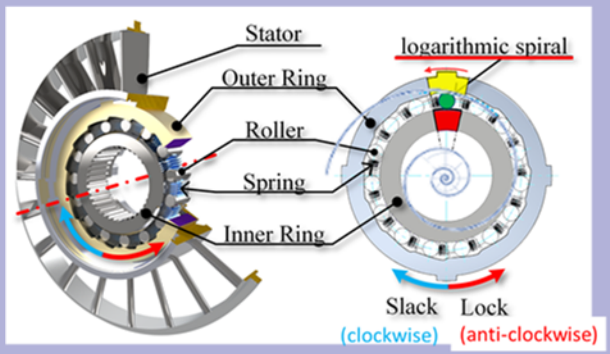


Figure 1: The Geometry Structure of One-way clutch and its Basic Components.

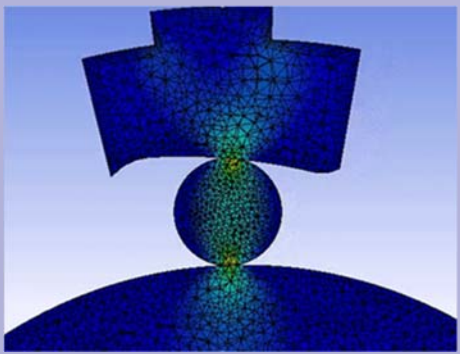


Figure 2: Explicit Wedging Process under Transient Loads

The results also prove that the self-lock performance of one-way clutch has close relationship to the wedge angle and the frictional coefficient, besides, more details of such wedging process can help better understand the one-way clutch and the function, as well as its further optimization in design.

Faculty Research

MAXBRG+ Development: Turbulence Implementation

Minhui He, Senior Scientist and Cori Watson-Kassa, Research Scientist

This project's goal is to develop a new version of MAXBRG, MAXBRG+, with features for improved turbulence modeling, a conduction-convection based hot oil carry-over model, speed improvements, and inertia modeling. The first phase of this project will focus on an improved turbulence modeling approached based on a modification of Prandtl's one equation turbulence model with thin film flow adapted length scale. Figure 1 shows a comparison of the cross film eddy viscosity profile for Reichardt's formula (currently used in MAXBRG and THRUST), direct numerical simulation (DNS, i.e. CFD with full turbulence resolution, assumed to be the true value), and the new methodology.

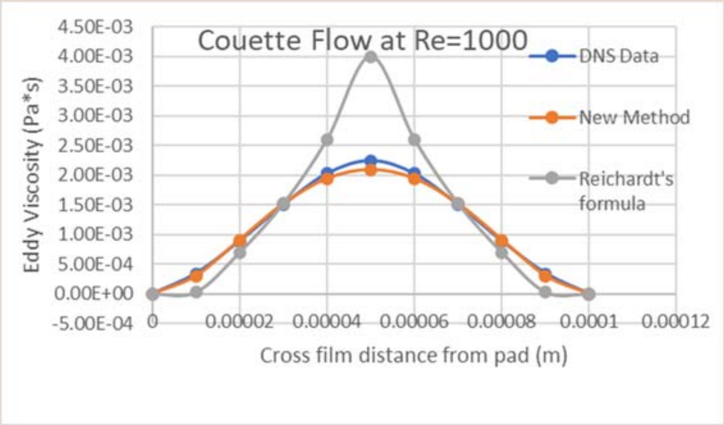


Figure 1: Cross film eddy viscosity profile

The results shown in the figure indicate that the new method is substantially more accurate than the existing model of Reichardt's formula. Additionally, this method has the add advantage that it does not require threshold Reynolds numbers to be specified by the user. The new method naturally adapts for turbulence transition as shown in Figure 2.

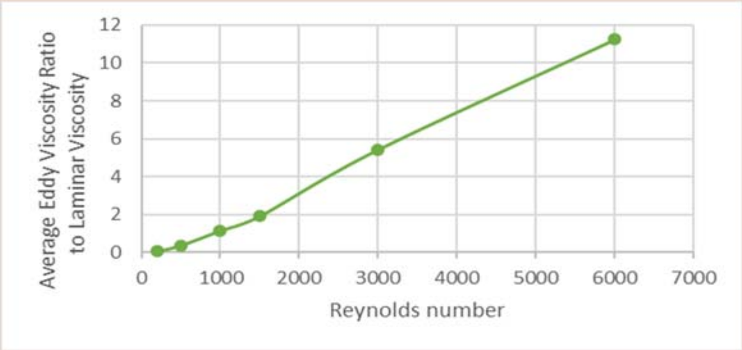


Figure 2: Cross film average eddy viscosity ratio to laminar viscosity versus Reynolds number.

Computational Fluid Dynamics Modeling of LEG versus Conventional Tilting Pad Journal Bearings

Cori Watson-Kassa, Research Scientist

Leading edge groove (LEG) bearings are a popular option to mitigate high peak temperatures present in high speed turbomachinery. Prior work has compared the temperature distribution of LEG and conventional tilting pad journal bearings through experimental techniques. However, the mechanism by which the LEG design exhibits lower temperature rise and lower peak temperature is not well understood. This study utilizes computational fluid dynamics (CFD) for a single pad of a five pad load-on-pad journal bearing with full thermal, groove mixing, and turbulence effects. The CFD results are matched closely to published experimental values. The analysis will show the mechanisms that causes the LEG pad to operate with a lower temperature rise. This study will also discuss the higher leading edge temperature of the LEG pad. Results are contrasted against Reynolds equation-based thermoelastohydrodynamic (TEHD) solver predictions to show the limitations of the existing models.

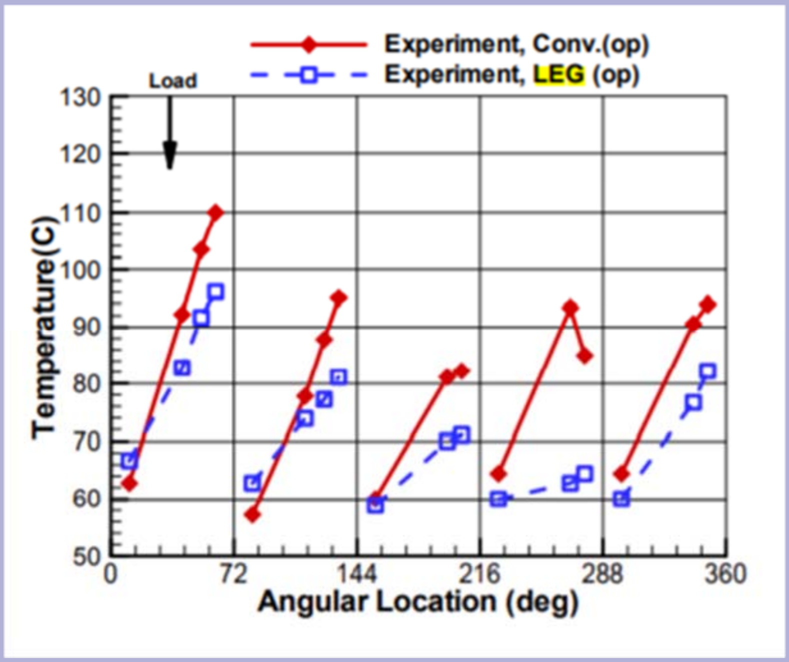


Figure: experimental thermal profiles for conventional and LEG five pad journal bearings (Brockwell et al 1994)

ROMAC Undergraduate Research Initiative

Based on the success of the 2019-2020 undergraduate research program, we have extended our undergraduate research work despite the pandemic. The goal of this program is to bring more value to the consortium by utilizing UVa's exceptional undergraduate students to extend the research conducted at ROMAC and the diversity of our research projects. We also hope this will help us recruit students into the field of rotating machinery for both ROMAC and industry

Pascale Starosta

Emily Hubbard

Kevin Moccia

Greg Breza

High Eccentricity and Statically Loaded Seal Rotordynamics

Student: Pascale Starosta
Expected Degree: BS Mechanical Engineering, minor in German May 2021

ROMAC is in the process of developing the high eccentricity and statically loaded seal codes. To test these codes, this project is looking at both cases and liquid and gas applications to validate CFD against test data and determine how the code compares to the CFD results. The results from this project will be used in the validation process for new seal codes that handle high eccentricity and statically loaded seals.

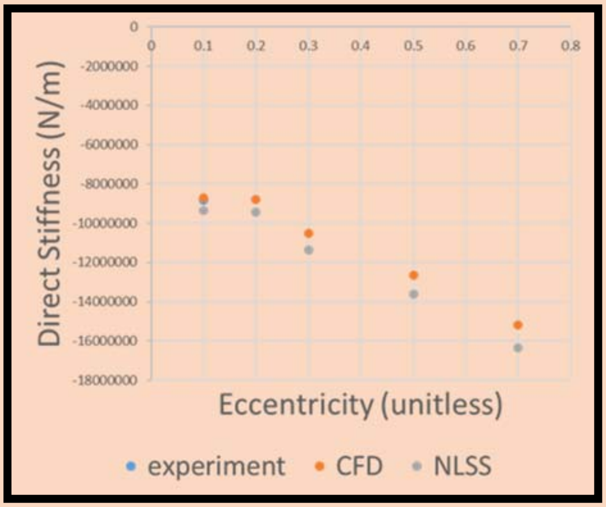


Figure: Direct stiffness versus eccentricity in CFD and new seal code, NLSS

Thermal Influence of Bearing Jacking Pockets

Student: Emily Hubbard

Expected Degree: BS Mechanical Engineering May 2021

MAXBRG3D was developed to include jacking pockets in its analysis. However, in its thermal analysis of jacking pockets, the thermal rise on the pad surface is considered zero in the pocket region. The goal of this project is to test out this hypothesis by thermally analyzing bearings with jacking pockets using CFD. Based on the results of this study, the thermal model of jacking pockets in MAXBRG3D can be adjusted to improve accuracy. Additionally, this project will show the impact of the thermal trends on the results of Branagan et al for stiffness coefficients of the bearings.

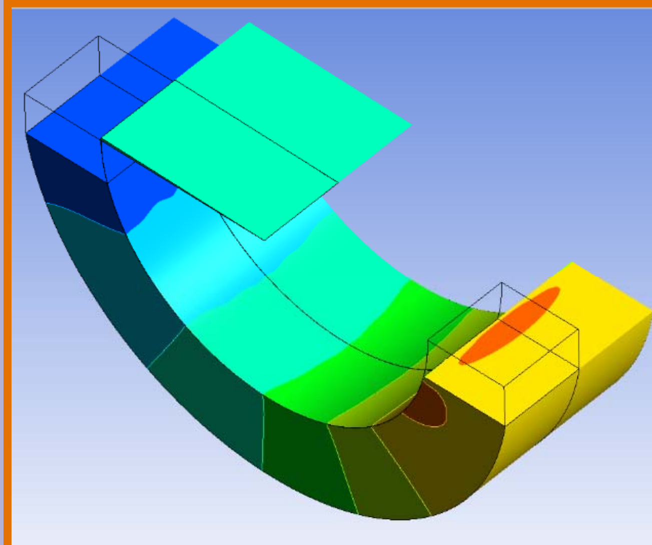


Figure: thermal variation on pad surface

Evaluating Helical Groove Seal Designs for Compressor Applications

Student: Kevin Moccia

Expected Degree: BS Aerospace Engineering, minor in Astronomy May 2022

Previous research has shown that helical groove seals can have lower leakage than labyrinth seals in compressible application. Additionally, helical groove seals have been found to have lower cross-coupling in experimental studies for both liquid and gas applications. The objective of this project is to design a helical groove seal that is optimized for the ROMAC Seal Test Rig. This seal will then be tested and compared with the existing hole pattern and smooth seal designs.

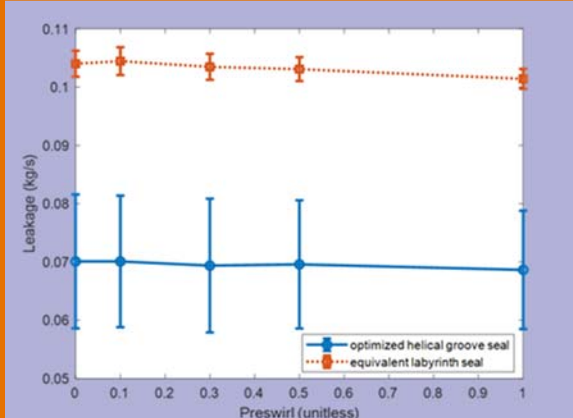


Figure: Leakage for helical groove and labyrinth seals versus preswirl

ROMAC Undergraduate Research Initiative

Comparison of Turbulence Model Selections for Compressible Applications

Student: Greg Breza

Expected Degree: BS Mechanical Engineering and Physics May 2022

For incompressible flow, such as those in bearings and liquid seals, research presented at the 2018 Annual Meeting has shown that the Eddy Viscosity Transport model is preferred for Reynolds numbers less than 1600, whereas the SST or k-epsilon models perform better at Reynolds numbers greater than 1600. The goal of this project is to determine similar turbulence model selection criteria for compressible flow in turbomachinery components. Specifically, the new Seal Test Rig at UVa will be used to generate a range of experimental data to compare against CFD data for various turbulence models

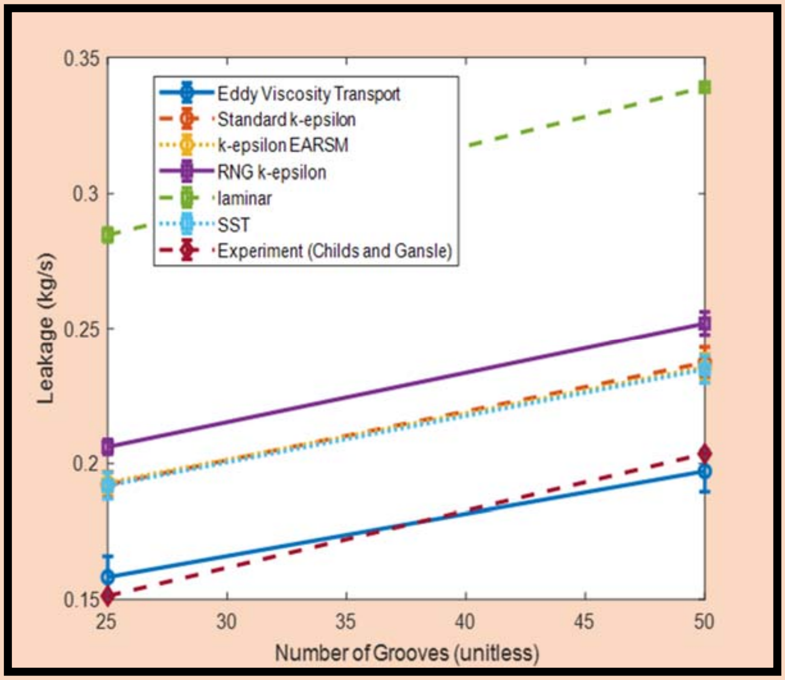


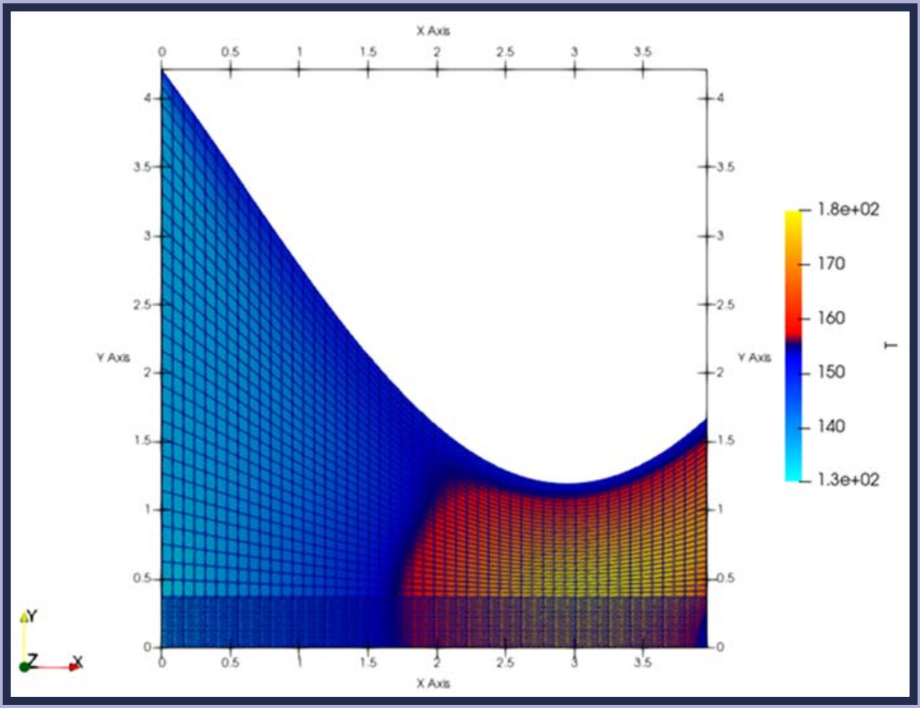
Figure: Turbulence model comparison to experimental results for a air helical groove seal

Fall 2020 Software Update

Neal Morgan, Software Engineer

RotorLab+ 4.4 was released at the end of this past summer. This latest version contained the following feature improvements and updates:

- Bug fixes and minor interface improvements for Maxbrg.



Paraview plots of Maxbrg

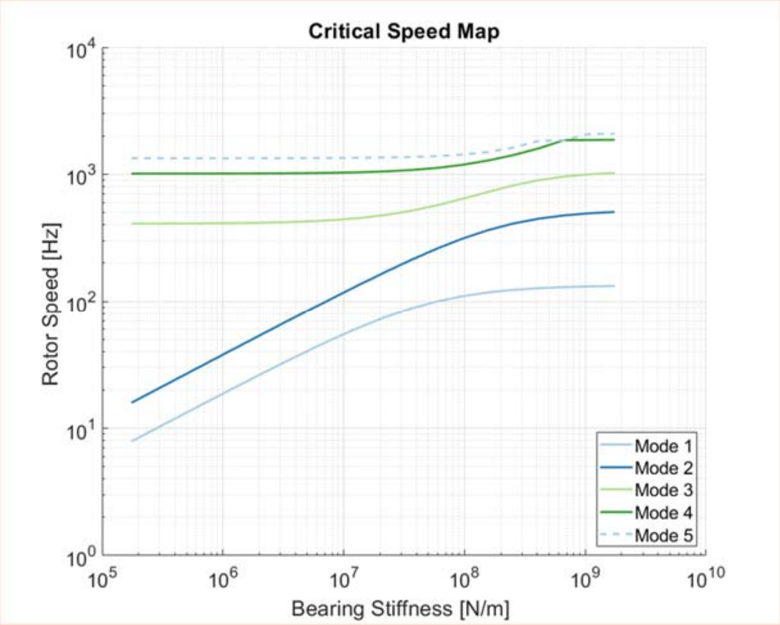
- Bug fixes for Rostb and Forstab's use of linked component bearings.
- Plotting improved for mode tracking in Rotstb.
- Bug fixes for handling mass distribution of overlapping geometry disks.
- Bug fix for SQFDamp saving inputs.
- Bug fix for component and shaft recoloration.
- Re-wording of Disk component definition labels and Tilting Pad Radial Bearing component input labels, and SQFdamp setup labels edited for clarity.
- Added capability to manage disk components that overhang the shaft ends.
- Added capability to manage disks with CG on geometric end of disk's connection to the shaft.
- Improved handling of disk components with overlapping nodes on the shaft

Fall 2020 Software Update *(con't)*

Ongoing plans for future software releases:

RotorLab+ 5.0 will be the next release and include the initial inclusion of RotorSol into RotorLab+ along with a few other improvements also listed below:

- Lateral mode analyses will be included to duplicate existing functionality from CrtSpd2, Forstab, and Rotstab.
- No existing features will be removed.
- SmoothSSeal, Seal4 and Laby4 will be included in version 5.0 or low 5.X following the competition of validation testing and documentation writing.



Axial and Torsional mode analyses are scheduled for validation testing and inclusion following the 5.0 release. These features will be included in future 5.X versions.

As part of our ongoing plans for improving the user experience, the RotorLab+ documentation is being updated. These updates will include features listed below:

- Clear descriptions and figures to relate each component input to physical system.
- Short Tutorials with clear time requirements and learning goals for each bearing and seal component analysis and for simple assembly analyses.
- Troubleshooting guides for each analysis type to handle simple convergence, user input, and stability issues.

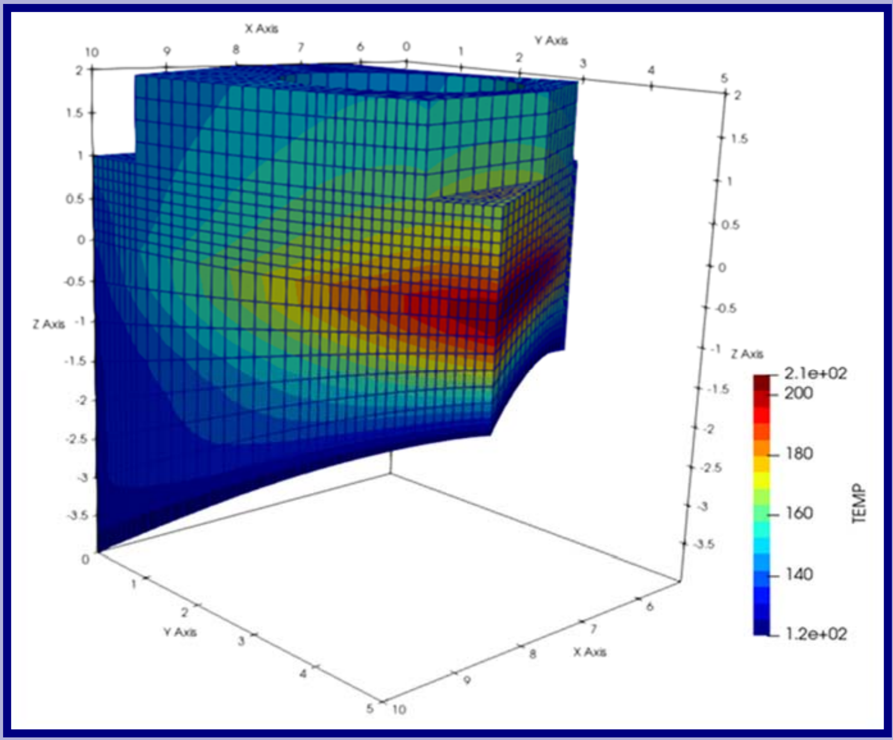
For questions about RotorLab+ or any ROMAC software visit our [website]

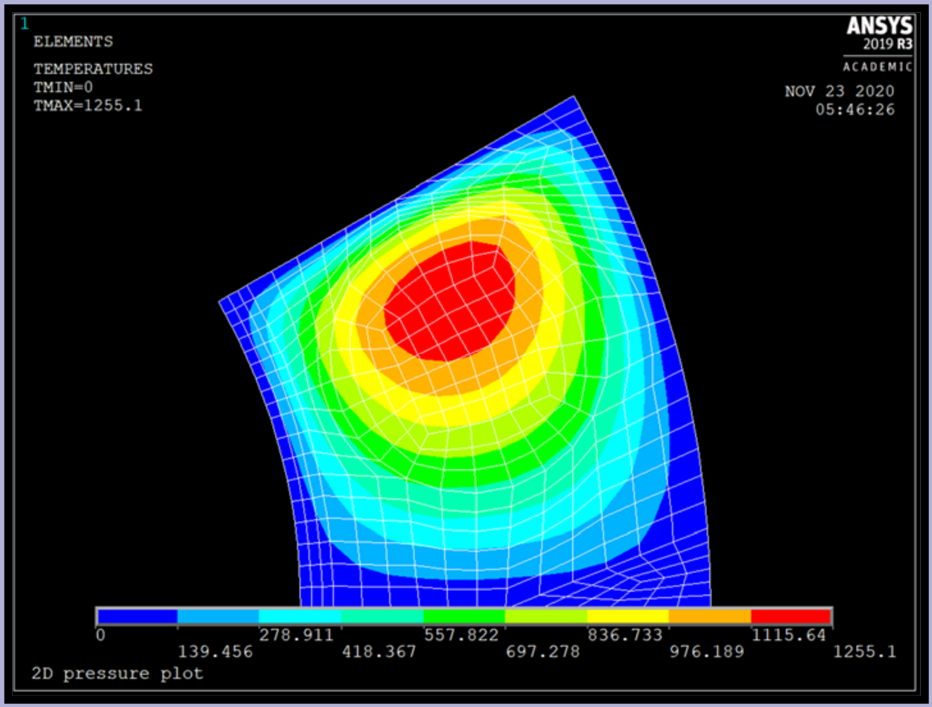
or contact us at [romac@virginia.edu]

Fall 2020 Software Update *(con't)*

We have also created instructional documentation for plotting the simulation results of MAXBRG and THRUST. These documents and some example templates are given in the respective software folders in our Member Resources repository.

THRUST image from Paraview





THRUST image from ANSYS

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Areas of Expertise and Current Research

- Software Development and Test Rig Validation
- Finite Element Analysis (FEA)
- Computational Fluid Dynamics (CFD)
- Fluid Film Bearings
- Seals
- Squeeze Film Dampers
- Rotordynamics
- Magnetic Bearings and Controls
- Optimization of Rotor-Bearing Systems
- Experimental, Computational, and Theoretical Studies

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