Polydopamine/PTFE Composite Coating for Large-Scale Journal Bearings in Next Generation Electric Machines

1467-1538

SurfTec, University of Arkansas, ABB

Period 1

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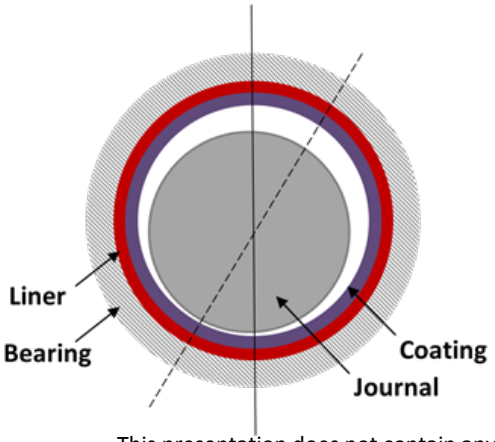
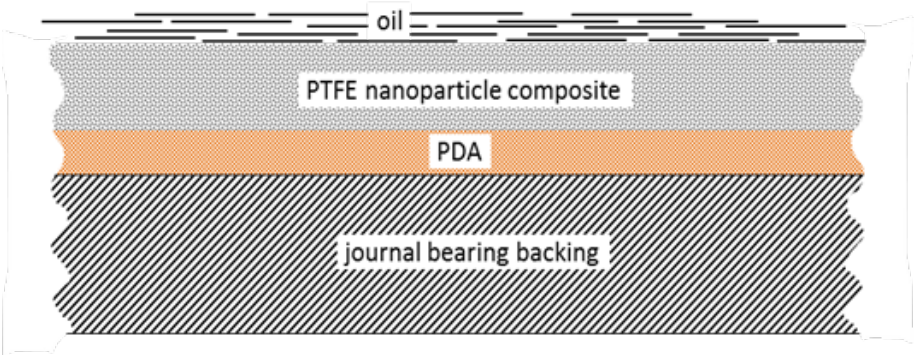
Project Objective

- Explore the use of a low-friction polydopamine/Polytetrafluoroethylene (PTFE) nanoparticle composite coating to replace traditional Babbit liners in large-scale journal bearings enabling the DOE AMO's goal of reducing energy losses in high speed, megawatt class, MV electric motors and generator systems while simultaneously removing lead and bismuth.
- Traditional Babbit liners in journal beaings contain lead and the disposal and use of lead and waste materials produced during fabrication presents an environmental issue.
- Lead is commonly used in bearings due to its low shear strength and low melting point, which results in a surface with lower friction compared to other soft metals.
- Bismuth is not a viable substitute for lead because it presents a supply chain risk.





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Fundamental Knowledge to be Gained

The goal of the proposed R&D is the optimization of **chemical concentrations**, **nanoparticle filler materials**, **porosity**, **coating thickness**, and **curing conditions** to tailor a low friction polymer for high load and high speed bearing applications. These parameters play a critical role in the wear, vibration, and friction resulting in bearings.

A thorough understanding of the process-structure-property relationship of SurfTec's coating will lead to new scientific knowledge that will be disseminated through applicable journals and trade publications.

Succesful completion of this project will serve as a ground breaking transition point from the use of outdated lubrication practices to state-of-the-art nano-coatings

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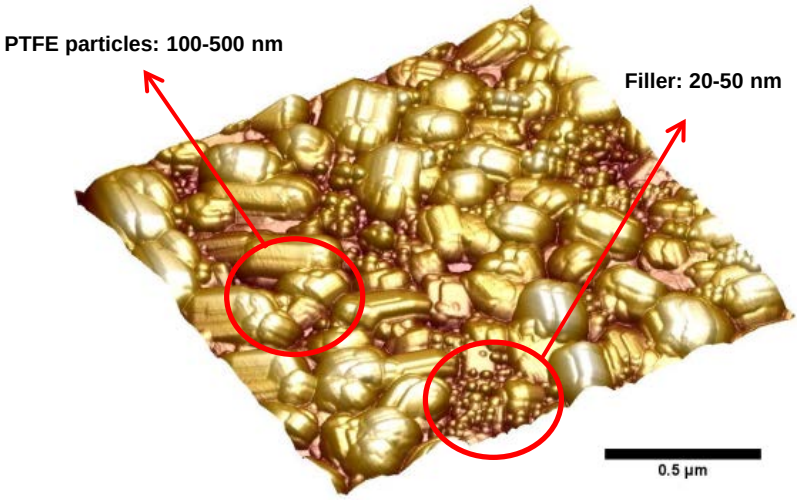
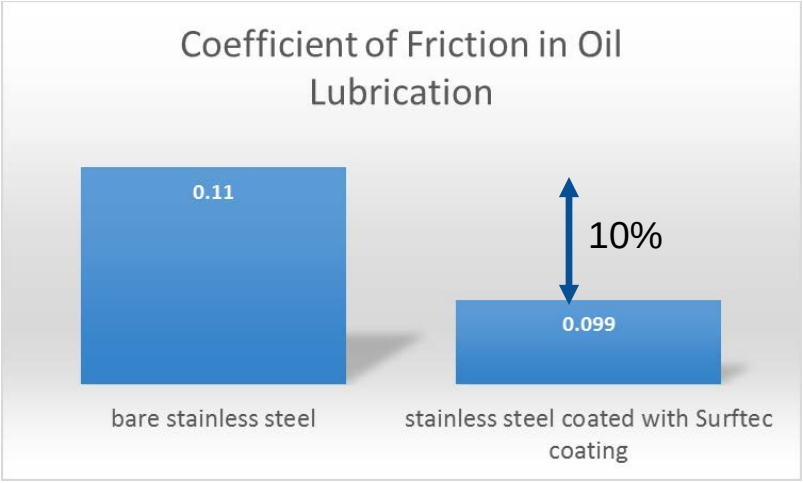
Technical Innovation

- Taditional Babbitt alloys today are composed primarily of tin and contain appreciable amounts of lead
  - function well during hydrodynamic lubrication
  - susceptible to high frictional losses during start/stop operation in electric motors.
  - The price of tin is currently $7.36/lb, significantly higher than other bearing materials. Cassiterite (tin) is considered a conflict mineral .
- SurfTec low-friction polydopamine/PTFE nanoparticle composite
  - reduce frictional losses by 10% and increase wear-life by 40%.
  - Polydopamine increases the wear-life of PTFE by over three orders of magnitude, allowing the use of low-friction PTFE to in more demanding applications.
  - Low cost ~ $0.01/in^2 , Low weight – 2 g/cm^3





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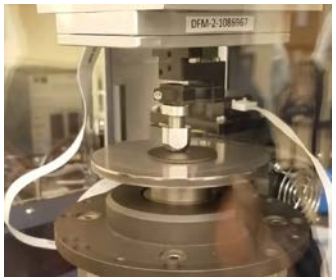
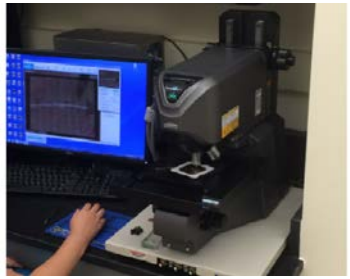
Technical Approach

Budget Period 1 - Coating Synthesis and Optimization / Benchtop Tribological Testing

Task performed by SurfTec and University of Arkansas Nanomechanics and Tribology Laboratory

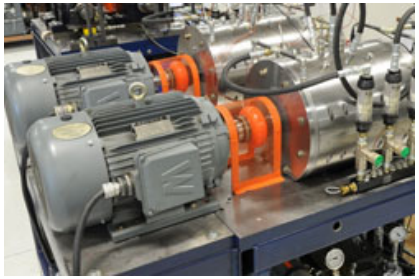
High resolution friction/wear testing





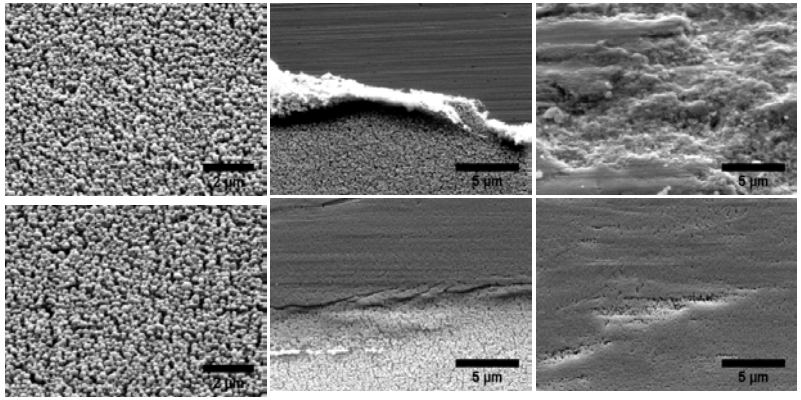
Surface characterization – atomic force microscopy, scanning electron microcopy

Bearing Tester Design/Assembly



http://www.nesbearings.com/

Coating Deposition Method Design



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Technical Approach

Budget Period 2 - Verification of coating performance in journal bearings and demonstration with a full scale prototype

Task performed by SurfTec and ABB

1. Key Technical Risks
   a. PTFE's non-wetting property may cause slip at the oil/PTFE interface and pose potential challenges in establishing fluid film lubrication.
   b. We have structured the proposed plan so that early tribological testing provides a go/no-go decision point based on overcoming these key risks.
2. Execution Attributes
   a. University of Arkansas Nanomechanics and Tribology lab has extensive experience in surface engineering and developing low-friction coatings, and is a key partner during the synthesis and optimization of the proposed coating.
   b. ABB is a world leader in power distribution, generation and transmission products and is a key partner to validate our technology in a full-scale prototype system. ABB also manufactures large-scale journal bearings and will serve as an entry point into the market.
   c. SurfTec founders have been developing the proposed technology for the past 7 years and have made significant progress in its performance.

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Applications of the Research

- Value
  - Our low-friction coating enables the DOE AMO's goal of reduced energy losses in high-speed megawatt-class MV electric motors and generator systems.
  - Reduces manufacturing costs for journal bearing manufacturers.
  - Enables electric motor and generator manufacturers to offer more efficient systems.
  - Aids US economy by reducing energy consumption.
- User
  - Bearing Manufacturer → Electric Motor Manufacturer → Power generation, transmission and distribution industry, oil and gas industry, hvac industry
- Commercialization approach
  - SurfTec has formed a key partnership with ABB, an electric motor, generator and bearing manufacturer. We have also partnered with leading bearing manufacturer GGB. We will leverage these partnerships to enter the market. SurfTec intends to follow a licensing business model.

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Measure of Success

- Success will be measured by 3 factors
  1. Increased bearing wear life >10%
  2. Reduced boundary and mixed lubrication frictional losses >10%
  3. Improved motor efficiency
- It is estimated that losses resulting from equipment downtime and maintenance due to poor lubrication across all industries in the US are as high as 6% of the GDP, a total of over $1 trillion for 2016.
- The implementation of SurfTec's coating technology will enable the following:
  1. Reduce oil consumption in bearings
  2. Extend service life in bearings and as a result in motors
  3. Reduce maintenance costs related to bearing failures
  4. Reduce energy consumption in electric motors

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Project Management & Budget

- The project has a duration of 2 years.

Key milestones	Anticipated completion
Design and assembly of bearing tester	Month 3
PDA/PTFE coating with COF <0.1 and wear life 100x higher than PTFE without PDA	Month 6
Demonstration of large scale coating process	Month 12
Demonstrated 50% reduction in frictional losses during dry operation, 10% reduction in lubricated conditions, and >10% increase in wear life in journal bearing.	Month 20
Full scale prototype system with improved electrical efficiency and frictional losses <50% during hard start and hard stop conditions comp. to lead containing bearings	Month 24

Total Project Budget	
DOE Investment	1,200,000
Cost Share	300,000
Project Total	1,500,000

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Results and Accomplishments

- We are in Month 1 of the project and are on task to complete the first milestone by end of month.
  - Bearing tester designed and Bill of Materials generated
- Work to be completed
  - Lab scale demonstration and optimization of coating performance in lubrication regimes relevant to hydrodynamic journal bearing operation and validation at a third-party test site. (Budget Period 1)
  - Scale up of coating deposition techniques to coat large scale journal bearings for megawatt class MV electric motors and generators and testing at partner motor and generator manufacturer. (Budget Period 2)
  - Inclusion of coated journal bearings in a full scale prototype system for demonstration and evaluation. Prototype system used as a test bed for performance validation. (Budget Period 2)

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