U.S. DEPARTMENT OF
ENERGY

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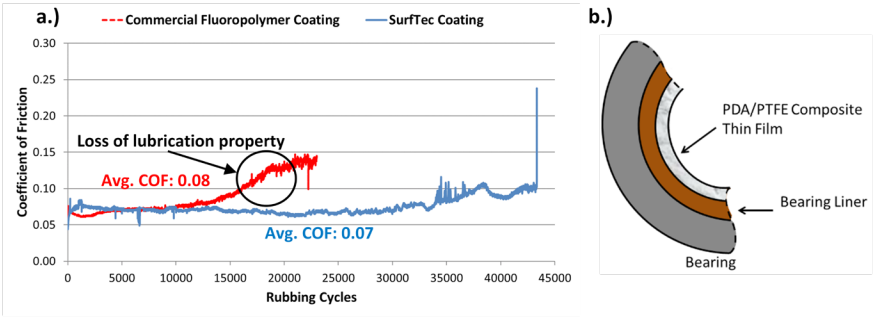
ENERGY EFFICIENCY & RENEWABLE ENERGY

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

Increasing the lifetime and reducing the energy consumption of large-scale electric machines through the use of innovative nanocoating

Electric motors are essential to the U.S. manufacturing sector, consuming approximately 68% of the sector's electricity. One of the vital elements of large megawatt-scale electrical machinery are the journal bearings that help to reduce friction, remove heat and debris, and protect other components of the motor system. Despite large-scale technology advances, journal bearings today are still based on 19th century designs of Isaac Babbitt, composed primarily of tin, with appreciable amounts of lead. Improving or replacing these traditional Babbitt bearings will help increase electric motor efficiencies, increase wear-life, and eliminate the use of expensive and environmentally problematic metals.

This project will develop a novel journal bearing nano-coating to replace the use of Babbitt bearings. The low-cost, low-weight nanoscale coating consists of a nanoparticle composite of polydopamine (PDA) and polytetrafluoroethylene (PTFE). The project will begin with a laboratory scale synthesis, optimization, and validation of coating performance, by testing in comparison with current bearing liner materials. The coating will be tested and scaled to an appropriate size for conventional large journal bearings at a third-party test site. Coating deposition techniques will also be scaled up for application at MW-scale electric motors and generators. After verifying coating performance, a full-scale prototype will be tested and evaluated.



(a) Plot of friction coefficients over rubbing cycle for SurfTec's proposed coating (blue) in comparison to a leading commercial coating. (b) Schematic of the proposed polydopamine/PTFE journal bearing liner coating. *Graphic image courtesy of SurfTec.*

Benefits for Our Industry and Our Nation

The PDA/PTFE coating under development can improve mechanical, friction, and wear properties while replacing conventional Babbitt alloys that contain lead. Lead bearings present environmental issues during disposal, and bismuth presents similar mechanical and wear properties with significantly lower production quantities. Using state-of-the-art journal bearing coating is expected to have a variety of benefits for large-scale electrical machines, including:

- Improved motor energy efficiency through reduced frictional losses by 40% (reducing dry friction by 30% and lubricated friction by 10% in boundary/ mixed lubrication regimes).
- Increased fatigue and wear life, by greater than 10%, helping to extend the service life of motors and reduce productivity losses due to equipment downtime and maintenance.

Applications in Our Nation's Industry

This low-friction, high-efficiency journal bearings technology will have a variety of benefits to manufacturers of high-speed megawatt-class MV electric motors and generator systems. Applications will include megawatt-class electrical machines that demand low-loss journal bearings and withstand hard-start/ hard-stop conditions. These devices are used in critical applications where technological reliability has a high cost. This technology is expected to replace traditional bearing liners used in these machines.

Project Description

The project objective is to develop, build, validate, and model a PDA/PTFE nanocomposite coating for journal bearings in next generation electric machines. The materials in the coating are expected to completely avoid use of conventionally used bearing materials, such as tin, lead, and bismuth. The project outcomes address supply chain steps: (a) benchtop verification of coating performance in tribiological tests and scaling of deposition methods to large scale journal bearings; and (b) verification of coating performance in journal bearings and demonstration with a full-scale prototype. The full-scale prototype should validate electrical efficiencies greater than 95% as well as a 10% reduction in frictional losses.

Barriers

- PTFE's non-wetting property may cause slip at the oil/PTFE interface and pose potential challenges in establishing fluid film lubrication.
- Full-scale prototype will need to successfully demonstrate improved performance and pass equipment manufacturer in-house bearing tests.

Pathways

The project is structured to address the key barriers and minimize risk for DOE. The ultimate goal is to produce a journal bearing coating for megawatt-scale electrical machines that can be subsequently commercialized.

The first project pathway will validate improved benchtop performance of the new nanocoating bearing material. This validation will compare performance with current bearing materials. Each of these laboratory-scale validations and optimizations will be completed at a third-party test site.

The second pathway will scale-up the coating deposition techniques. These deposition techniques will be applied to coat larger journal bearings for megawatt-scale electric motor and generators. In addition, these techniques will be tested at a partner motor and generator manufacturer.

The third pathway will validate the durability of the coating. This will be accomplished through bearing tests and fabrication of a full-scale prototype system. This will be done to monitor machine performance improvements resulting from reduced friction.

Milestones

This two year project began in 2017.

- Lab-scale validation and optimization of coating performance in lubrication regimes relevant to hydrodynamic journal bearing operation (2018).
- Scale-up of coating deposition techniques to coat journal bearings for megawatt class MV electric motors and generators and testing at partner motor and generator manufacturer (2018).
- Inclusion of coated journal bearings in a prototype system for validation and evaluation. Prototype system used as a test bed for performance validation (2019).

Technology Transition

SurfTec is partnering with the University of Arkansas and ABB Group for the design, fabrication and testing of these novel journal bearing coatings. Following successful development, this coating could be initially introduced to smaller electrical machinery at the discretion of the equipment manufacturer. The bearing could then be gradually adopted at larger scale electrical machinery. SurfTec plans to manufacture the coating initially, and then license it primarily to bearing manufacturers. In order to realize these transition efforts, SurfTec anticipates that additional funding will be required. The team plans to present to programs like the Arkansas Economic Development Program (AEDC), as well as local angel and venture capital groups.

Project Partners

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