ORNL CPS #36333 Vertically-Aligned Carbon Nanotube Arrays as Novel Self-Lubricating High-Efficiency Brush Seal for CSP Turbomachinery

A Carbon Nanotubes-Based Seal Technology for Improved Energy Efficiency of CSP Turbomachinery

1. Impact

Potentially resulting in 1-3% energy savings to help meet the SETO CSP 2030 target.

2. Project Goal

To develop a novel self-lubricated, zero-clearance seal using carbon nanotubes to improve the seal's efficiency and durability with a lower manufacturing cost for CSP turbomachines.

3. Method(s)

Identification of seal requirements, modeling, seal design, optimization of CNT growth, materials characterization, prototype fabrication, seal testing, and data analysis.

4. Outcome(s)

Significant technical progress has been made after BP-1: achieved 95-100% surface coverage by CNTs of good crystallinity (IG/ID: 2-3.5), demonstrated superlubricity (friction coefficient <0.01) for the CNT-covered surface, assembled a large-size chemical vapor deposition system to accommodate actual seal base structures, designed a new CNT-metal hybrid seal for addressing the limitations of CNT length and bonding strength. Initial seal testing on the CNT-based seal suggested great potential in improving the sealing efficiency. An ORNL Invention Disclosure 202104914, "A high-efficiency seal composed of carbon nanotubes" has been submitted. Table 1 compares the CNT-based seal technology with the state-of-the-art seals.

5. Conclusion/Risks

Two major technical challenges in BP-1 were limited CNT length and relatively weak bonding of CNTs to the seal base. An innovative hybrid CNT-metal seal has been designed to mitigate both risks with great potentials for increased sealing efficiency and reduced cost compared with the state-of-the-art brush seals.

6. Team

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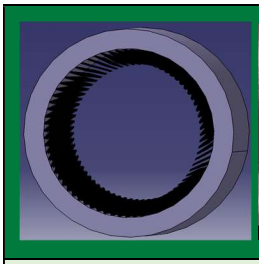
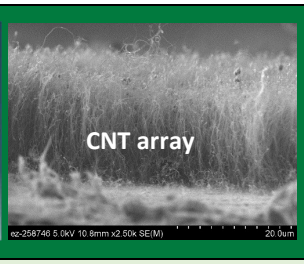
Table 1. Comparison between the CNT-based seal and the conventional and state-of-the-art seals

 		Sealing efficiency	Durability/ reliability	Shaft protection	Cost ($)
CNT-based seal technology in this project		**Very high**	**Excellent**	**Excellent**	**<50**
Conventional Labyrinth seal		Medium	Ok	Ok	<30
State-of-the-art brush seals	Metal brush seal	Medium-High	Poor	Poor	600
	Carbon fiber brush seal	High	Poor	Good	600
	Kevlar brush seal	High	Good	Good	1800