

## Tubercles for ORC Turbine Efficiency: Biomimicry Improves Energy Recovery

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<https://infinityturbine.com/infinity-turbine-turbucles-foil-design.html>

Inspired by humpback whales, tubercle technology used in airfoil design may reduce drag in Organic Rankine Cycle (ORC) turbines. This article explores the feasibility and benefits of applying tubercles to turbine blade design.



This webpage QR code

**PDF Version of the webpage (maximum 10 pages)**

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## Tubercles for ORC Turbine Efficiency

Can a humpback whale's flipper help your turbine run more efficiently? Discover how tubercle-inspired designs are showing promise for boosting the performance of ORC turbines by reducing drag and turbulence.



## Tubercles for ORC Turbine Efficiency: Biomimicry Improves Energy Recovery

Tubercles—those distinct rounded bumps on the leading edges of humpback whale flippers—have become a subject of engineering interest due to their aerodynamic benefits. Originally studied for application in wind turbine blades and airfoils, tubercles have shown the potential to reduce drag by up to 20 percent and delay stall by managing airflow in a more stable, controlled manner. This raises the question: can the same concept be applied to the blades of Organic Rankine Cycle (ORC) turbines to improve efficiency?

### What Are Tubercles?

Tubercles are non-uniform, sinusoidal protrusions placed along the leading edge of a wing or blade. They work by channeling airflow into smaller, controlled vortices, reducing flow separation and turbulence, which in turn lowers drag and increases lift in aerodynamic contexts.

### Potential in ORC Turbines

In an ORC system, working fluids such as refrigerants or superheated organic compounds flow through a turbine to generate electricity. Turbine efficiency is highly dependent on smooth, laminar flow across the blades. Introducing tubercles to turbine blade design—particularly on axial or radial turbines—could manage flow more predictably, especially under off-design or variable load conditions.

Computational Fluid Dynamics (CFD) simulations and experimental studies in air-based systems suggest that tubercled blades could reduce flow separation, suppress wake formation, and improve overall turbine efficiency. While the working fluid in ORC systems differs from air, the principles of fluid dynamics remain applicable. Early studies are encouraging but remain largely theoretical or limited to small-scale prototypes.

### Benefits and Challenges

#### Potential Benefits:

- Reduced flow separation and secondary losses
- Improved blade loading distribution
- Enhanced off-design performance and efficiency stability
- Noise reduction (a secondary benefit in sensitive applications)

#### Challenges:

- Complex manufacturing geometry, especially for high-speed turbine rotors
- Need for ORC-specific testing with working fluids like R245fa, R1233zd, or supercritical CO<sub>2</sub>
- Trade-offs between mechanical strength and aerodynamic gains

### Future Applications

If validated for ORC applications, tubercle-enhanced turbine blades could find uses in low-grade waste heat recovery, geothermal plants, and compact power modules for industrial processes. As 3D printing and advanced manufacturing methods continue to evolve, the cost and complexity of producing non-traditional blade geometries may decrease, opening the door for broader commercial implementation.

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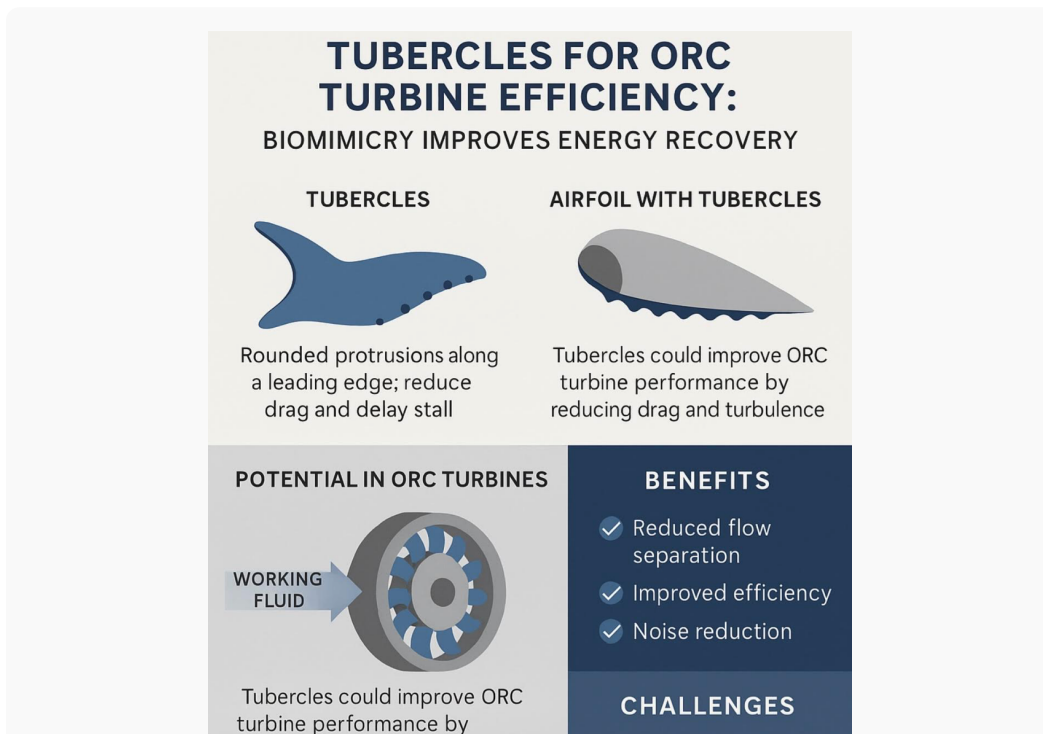
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### Conclusion



reducing drag and turbulence

### FUTURE APPLICATIONS



Waste heat recovery  
Geothermal power  
Other ORC systems

- ✗ Manufacturing complexity
- ✗ Limited testing with ORC turbines
- ✗ Mechanical trade-off

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## TUBERCLES FOR ORC TURBINE EFFICIENCY:

BIOMIMICRY IMPROVES ENERGY RECOVERY

### TUBERCLES



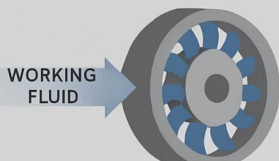
Rounded protrusions along a leading edge; reduce drag and delay stall

### AIRFOIL WITH TUBERCLES



Tubercles could improve ORC turbine performance by reducing drag and turbulence

### POTENTIAL IN ORC TURBINES



### BENEFITS

- ✓ Reduced flow separation
- ✓ Improved efficiency
- ✓ Noise reduction

Tubercles could improve ORC turbine performance by reducing drag and turbulence

### FUTURE APPLICATIONS



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