



Through-Coolant Turbine Shaft for Organic Rankine Cycle Increases Efficiency and Bearing Life

**Infinity Turbine
LLC**

[TEL] 1-608-238-6001

[Email] greg@infinityturbine.com

<https://infinityturbine.com/through-coolant-turbine-shaft-orc-better-performance-by-infinity-turbine.html>

Infinity Turbine introduces a through-coolant spindle-shaft design for Organic Rankine Cycle (ORC) systems that improves bearing performance, enables liquid-cooled in-situ condensation, and boosts overall efficiency and turbine pressure ratio.



This webpage QR code

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Through-Coolant Turbine Shaft for Enhanced ORC Performance

Organic Rankine Cycle (ORC) systems recover waste heat from low-temperature sources such as data centers, geothermal wells, or industrial exhaust streams. Traditionally, the turbine shaft in such systems operates under high thermal gradients and mechanical stress, with heat buildup adversely affecting bearing life and turbine efficiency. To address this, Infinity Turbine has developed a through-coolant spindle-shaft design, inspired by high-speed machine tool spindles and advanced aerospace cooling architectures.

Concept Overview

In this configuration, a coolant—typically the working fluid or a secondary loop liquid such as water, glycol, or dielectric oil—is circulated through internal channels within the turbine shaft. The coolant enters through a rotary union or stationary feed manifold, passes through the shaft's hollow core, and exits at a controlled temperature and flow rate.

This approach offers two key advantages:

1. **Active Shaft Cooling:** Reduces thermal expansion and bearing temperature, allowing tighter tolerances and higher RPMs without lubrication degradation.
2. **Integrated Liquid-Cooled Condensation:** The same coolant flow can be directed toward in-situ condenser channels near the turbine outlet to condense vapor directly at the turbine housing, minimizing losses in the external piping and condenser stage.

Performance Benefits

1. Improved Bearing Life:

Lower shaft and bearing temperatures can extend bearing lifespan by a factor of two to three. For precision ceramic or magnetic bearings, this stability enables continuous operation at higher rotational speeds (up to 10–20 % higher).

2. Reduced Friction and Lubricant Breakdown:

Maintaining the bearing region below 80 °C prevents viscosity loss in lubricants or degradation in gas-foil bearings, improving long-term reliability.

3. Higher Pressure Ratio and Efficiency:

By integrating in-situ condensation, the exhaust vapor is condensed immediately adjacent to the turbine outlet. This reduces exhaust back-pressure and increases the effective expansion ratio across the turbine.

- Estimated increase in pressure ratio: 5 – 8 %.

- Corresponding turbine efficiency gain: 3 – 5 %.

- System-level ORC net efficiency improvement: approximately 2 – 3 %.

4. Compact, Modular Design:

Integrating cooling and condensation into the turbine shaft and housing eliminates the need for bulky external condensers, allowing smaller, modular turbine power blocks ideal for distributed waste-heat recovery systems.

Engineering Considerations

- **Coolant Path Geometry:** A spiral or helical channel inside the shaft maximizes surface area and uniform heat removal.

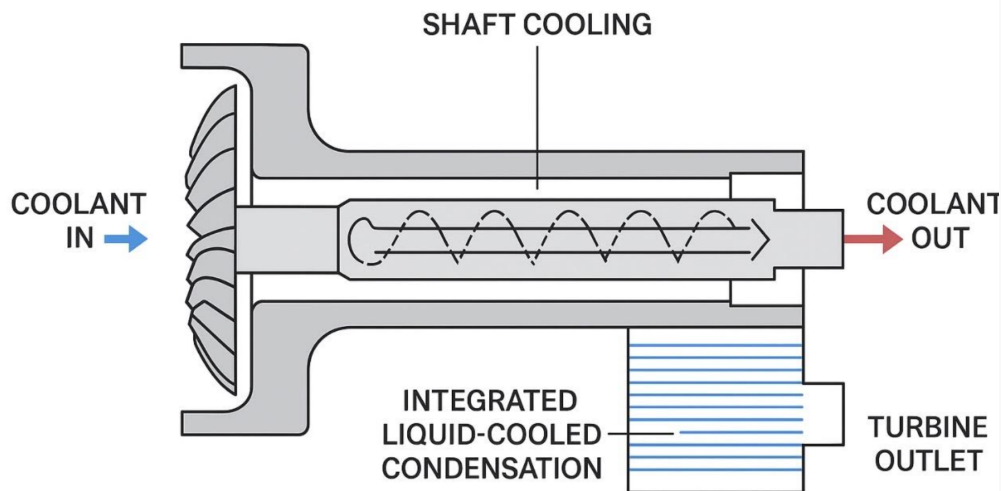
- **Sealing Method:** Rotary union or magnetic coupling for minimal leakage and maintenance.

- **Fluid Compatibility:** The coolant loop should be isolated if different from the ORC working fluid (e.g., R245fa or sCO₂).

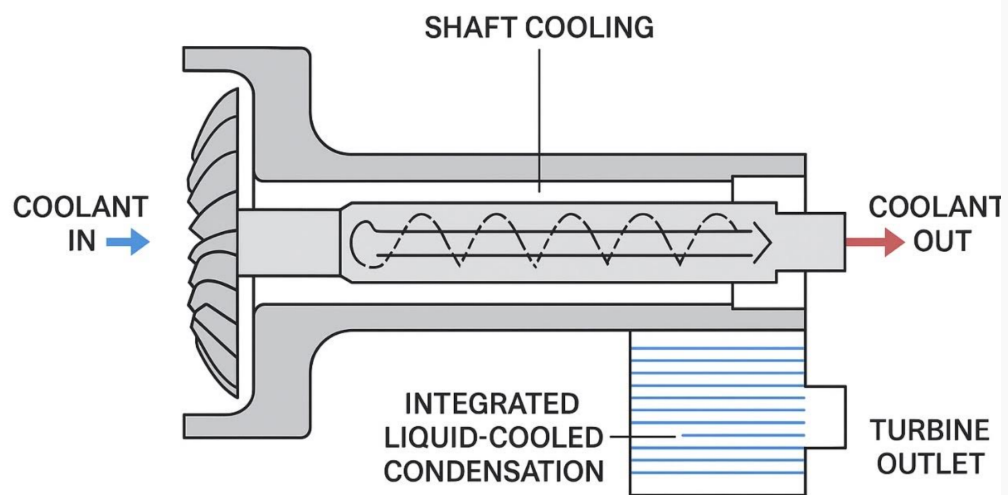
- **Thermal Expansion Management:** Active cooling allows tighter axial clearances and prevents bearing preload shifts.

Conclusion

The through-coolant turbine shaft concept represents a next-generation mechanical-thermal integration for Organic Rankine Cycle turbines. By combining shaft cooling, bearing stabilization, and in-situ condensation, this design not only improves mechanical reliability but also enhances cycle efficiency and pressure ratio—achieving greater output power from the same waste-heat input.



THROUGH-COOLANT TURBINE SHAFT FOR ORGANIC RANKINE CYCLE



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