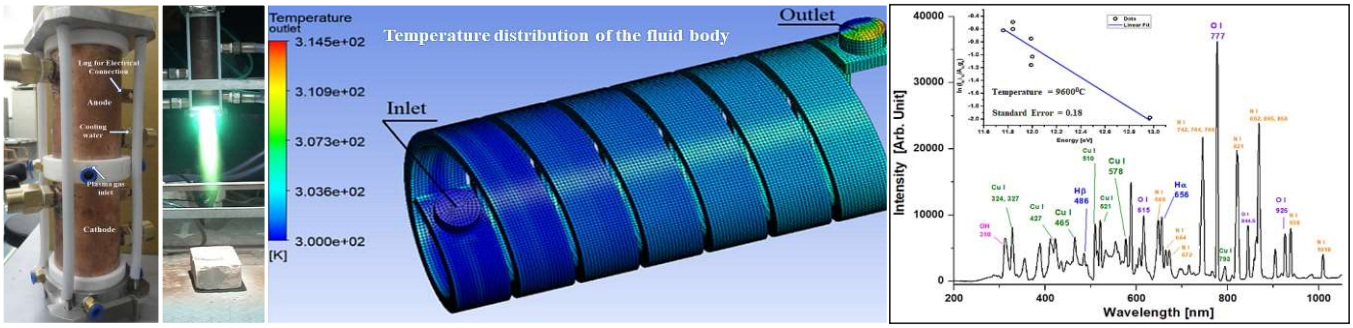
In-house Developed 100 kW Hafnium-free Cu Electrode Based Plasma Torch

Clocks Cumulative 100 hours of Operation with Potential for Further Longevity



Left to right: *The fabricated device; 100kW Thermal Plasma; Temperature distribution of the fluid body; Emission spectrum of air plasma at 100kW power (with Measured plasma temperature in the inset graph).*

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The indigenously developed torch has operated reliably for over 100 hours without electrode replacement.

High-power (~100 kW) air thermal plasma torches are crucial for industrial processes like cutting, welding, spraying, and waste treatment, thanks to their ability to generate dense plasma at 5000–10,000°C. Air as the plasma gas makes them eco-friendly and economical. Our indigenously developed torch has operated reliably for over 100 hours without electrode replacement, enabled by several key innovations:

- Advanced Cooling Channel Design: A helical cooling water channel, developed through thermal simulations, effectively manages the torch's thermal load and ensures operational stability.
- Electrode Innovation: The torch employs a hollow, hafnium-free Cu based electrode design, improving sustainability and reducing operational costs.
- High Plasma Temperature: Spectroscopic analysis confirmed plasma temperatures approaching ~9600°C, supporting its suitability for high-performance industrial tasks.
- Novel Arc Rotation Mechanism: A unique method of utilizing the magnetic field generated by the input power cable enables arc rotation, significantly reducing localized electrode erosion. This innovation has been critical in achieving the 100-hour electrode life.

These advancements position the device as a reliable and efficient solution for industries seeking durable, high-power, and environmentally friendly thermal plasma systems.

Some part of this highlight has been published in International journal, Vacuum, titled "Increasing life & efficiency of a 100 kW hollow cathode air plasma device with helical water channel design: Operational insights through optical emission spectroscopy" [Ref: Vacuum 234 (2025) 114065].