APPLIED PLASMA TECHNOLOGIES
Research & Development

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APT-100 series ICP/RF plasma systems

Application: The 2nd generation ICP/RF (radio frequency) plasma system with regulated up to 40 kW power in plasma plume (depends on many factors, including plasma gas) is developed for continuous operation on different gases, including Ar, air, N_2, CO_2, blends of air and O_2, Ar + O_2, Ar + N_2, and others with pressure at the torch output from several Torr to 7 bar. The system allows remote plasma initiation at 1 bar pressure, automatic switching of plasma gases, visualization of the operation parameters as real plasma power and temperature, plate voltage and current, grid current, consumed from grid power, temperature and flow of water in the cooling loops, data logging, etc.

Components: The plasma system consists of a direct current (DC) Module with dimensions 30" x 42" x 60", weight 800 kg (standard) and 32" x 45" x 62" (advanced); Radio-Frequency (RF) Module with dimensions 32" x 32" x 60", weight about 300 kg; coaxial cable 2-2.7 m; Matching Network 12" x 12" x 25", and plasma torch. Optionally, an integrated gas supply system for two or three gases with dimensions 4" x 4" x 6" pre-calibrated for 6 gases, and remote operator's console are available.

Parameters:

- Input voltage – 3 x 480VAC, 60 Hz or 3 x 380VAC, 50 Hz
- Input power – 100 kVA max, 125 A (standard)/ 110 kVA or 125 kVA (advanced)
- Output voltage – up to 14,000 V
- Frequency – 3-7 MHz depending on application and product destination
- Cooling water – input 3/4" NPT female, output 1" NPT female. Flow rate for full power operation is 35-50 liters per minute
- Plasma gas flow – from 0.5 to 5 g/s (depending on gas composition and torch power).

Control system.

- Standard control system provides manual operation and main parameters visualization, as anode voltage and current, grid current, anode and plasma power, input and output water temperature, water temperature after tube, and water flow rate on two text displays
- Advanced control system allows selection of manual and automatic operation modes from a 12-inch touch screen. Additionally to a set of functions for the standard system, we offer automatic ignition at 1 bar pressure, transition to different plasma gases, filament voltage control, remote flow and power control, plasma stabilization, data logging, gas valves monitoring, diagnostic tools with numerous user prompts, remote control from the operator's console or through profibus, and many others.

  Front panels of the DC modules with standard and advanced control systems are depicted in Fig.4 and Fig.5 correspondingly.

Prospective applications :

(1) Advanced and economical test facility for the Ablative Thermal Protection Systems (TPS) materials. Compared to well known arc-jet facilities based on direct current (DC) torches, RF plasma provides such advantages, as much better uniformity of the

temperature and velocity fields in a plume cross section, significantly larger plume OD with lower power consumption, contamination-free plasma, longer service time due to electrodeless design, wider range of plasma/test gases, continuous (thousands of hours) non-stop operation, and others. The test bed should provide experiments with materials for velocity >11.5 km/s (Earth return), with requirements to survive heat fluxes of 1.5–2.5 kW/cm2, with radiation contributing up to 75% of that flux, and integrated heat loads from 75–150 kJ/cm2.

(2) Synthesis of new materials - solids and gases
(3) Gasification of different feedstock - coal, sewage sludge, etc.
(4) Powders processing for surface modifications, minerals extraction
(5) High flow and concentration NOx production – by 7% (mass).

Services: development, production, commissioning, and worldwide service of technologies based on ICP/RF plasma within the power range 20-500 kW.

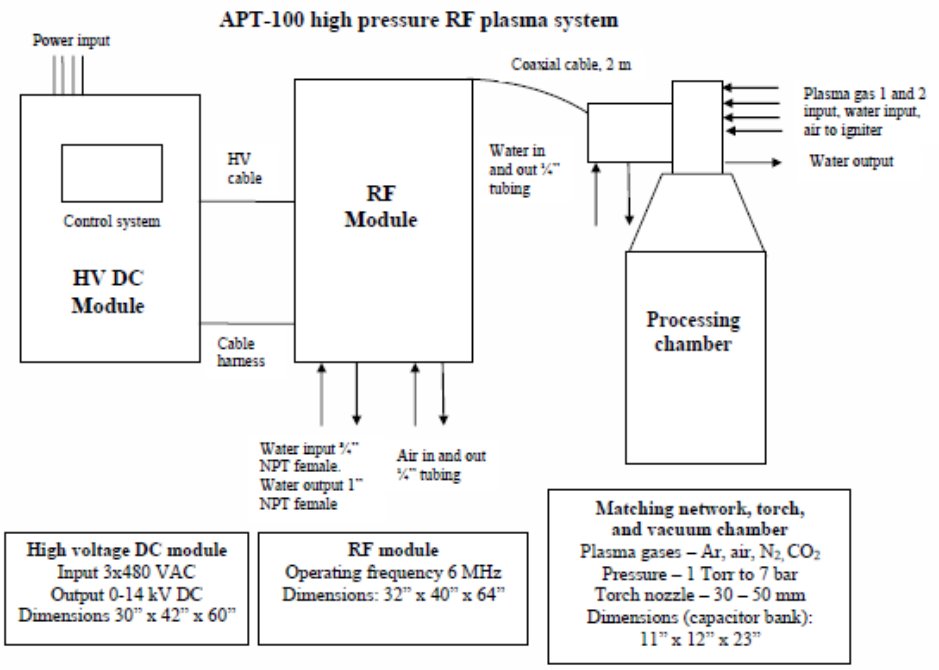

Fig.1. Configuration of a test bed for characterization of thermal protection materials.

	Parameter	Value
1	Flow OD at the torch output (before supersonic nozzle), mm	30–50
2	Plasma gases	Ar, air, N_2, CO_2, oxygen enriched air, other
3	Test gas flows, g/s	1.0 - 5.0
4	Free stream enthalpy, MJ/kg	3.0 – 40.0
5	Free stream velocity, M	0.02–7.0
6	Average test gas temperature, °C	2,000 – 6,000
7	Operation pressure (pressure in induction section)	1 Torr to 7 bar
8	Stagnation pressure maximal, kPa (mBar)	80 (800)
9	Maximal power consumption, kW	87/100

Fig.2. General view of the APT-100-1 plasma system for material tests

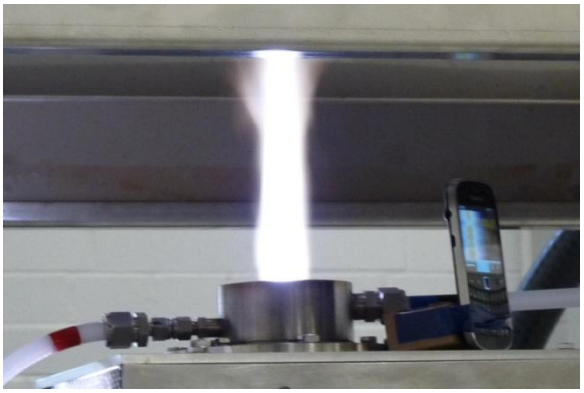

Fig.3. 30 mm OD plasma plume. Gas – air

Fig.4. Front door of the APT-100-2 DC module with standard control and 3-gas supply systems

Fig.5. Front door of the APT-100-3 DC module with advanced control system

Fig.6. Rare door of the APT-100-5 DC module with remote main power On/Off function

Fig.7. Remote operator's console

Fig.8. APT-100-5 operation and plasma diagnostics by optical spectroscopy