APT-100 series ICP/RF plasma systems
(for advertising purposes only)

Application: The 2nd generation ICP/RF (radio frequency) plasma system with regulated up to 40-50 kW power in plasma plume (depends on many factors, including plasma gas) is developed for continuous operation on different gases, including Ar, air, N₂, CO₂, blends of air and O₂, Ar + O₂, Ar + N₂, 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 plate voltage and current, grid current, consumed from grid power, temperature and flow of water in three cooling loops, real plasma power, data logging, etc.

Components: The plasma system consists of a direct current (DC) Module with dimensions 30” x 42” x 60” or similar, weight 800 kg; 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, a gas supply system for two or three gases with dimensions 4” x 4” x 6” 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 – 90 kVA to 140 kVA depending on modification
- Output voltage – up to 14,000 V
- Frequency – 2-7 MHz
- Cooling water – input 3/4” NPT female, output 1” NPT female. Flow rate for full power operation ≥ 35 liters per minute. Several options of the cooling system are available upon request. The exact specification is a subject for negotiations.
- Plasma gases flow – from 0.5 to 5 g/s (depending on gas composition and 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 are the first in the field to offer automatic ignition, transition to different plasma gases, remote flow control, plasma stabilization, plasma plume temperature indication, data logging, smooth power control, filament voltage control, 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, the 2nd generation 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, flexible design of the exit nozzle, 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 NO and NOx production.

**Services:** development, production, commissioning, and worldwide service of technologies based on ICP/RF plasma within the power range 30-500 kW.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>1 Flow OD at the torch output (before supersonic nozzle), mm</td>
<td>30–50</td>
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<tr>
<td>2 Plasma gases</td>
<td>Ar, air, N2, CO2, oxygen enriched air, other</td>
</tr>
<tr>
<td>3 Test gas flows, g/s</td>
<td>0.5–5.0</td>
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<tr>
<td>4 Free stream enthalpy, MJ/kg</td>
<td>3.0–40.0</td>
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<tr>
<td>5 Free stream velocity, M</td>
<td>0.02–7.0</td>
</tr>
<tr>
<td>6 Average test gas temperature, °C</td>
<td>4,000 – 10,000</td>
</tr>
<tr>
<td>7 Operation pressure (pressure in induction section)</td>
<td>1 Torr to 7 bar</td>
</tr>
<tr>
<td>8 Stagnation pressure maximal, kPa (mBar)</td>
<td>80 (800)</td>
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<tr>
<td>9 Maximal apparent power consumption, kVA</td>
<td>100</td>
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Fig.1. Configuration of a test bed for characterization of thermal protection materials.
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