GLIDING ARC PLASMA REACTOR
AND ITS POWER SUPPLY SYSTEMS

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Lublin University of Technology

6 faculties
11,000 students
1000 total staff
83 professors

Seat of University President and Council

Research labs in the CoE Asppect

Faculty of Management Science and Engineering Training

PlasTEP+ Workshop “Plasma for Environmental and Energy Applications”, February 13, 2014, Uppsala
The major research and development areas in the COE ASPPECT and Institute of EE&Et of LUT

Plasma Technologies in Environment Protection
- industrial ozone generators and water conditioning,
- plasma reactors to remove gaseous pollutants,
- electrical supply systems for ozonizers and plasma reactors,
- bio-medical application: sterilization, disinfection, skin treatment,
- mathematical modeling of the arc discharge reactors.

Superconductivity Application
- superconducting magnets, their design,
- construction and application,
- superconducting fault current limiters,
- magnetic OGMS separators,
- superconducting magnetic energy storage systems (SMES).
Electromagnetic Compatibility
- electromagnetic field influence on living organisms,
- shielded chambers for electromagnetic measurements,
- monitoring of electromagnetic interferences,
- soft magnetic materials, their applications in power devices and electronics,
- non-linear circuits with magnetic elements,
- electromagnetic field calculations.

Renewable Energy Sources
- power systems for discharge devices,
- REN cooperation with power grid.
OUTLINE

- Gliding arc plasma reactor
- Power supply systems for gliding arc plasma reactors
- Experimental results
- Conclusion
GLIDING ARC PLASMA REACTOR

Fig. 1. Gliding Arc plasma reactor

1 – discharge chamber,
2 – nozzle,
3 – ignition electrode,
4 – working electrode.
Fig. 2. Gas supply system:
1 – plasma reactor, 2 – electronic control system,
3, 4, 5 – flow rate controller, 6, 7, 8 – working gases.

Fig. 3. Flow rate controller

Working gases:
- argon,
- nitrogen,
- air.
GLIDING ARC DISCHARGES FOR DIFFERENT POWER SUPPLY SYSTEMS

Fig. 4. Working gliding arc plasma reactor supplied from different power systems

a – integrated power supply system based on transformers with the soft external characteristic;

b - power supply system based on transformers with the amorphous limbs (Metglas) with external ignition system;

c - power supply system based on five-limbs transformer.
EXTERNAL CHARACTERISTICS OF SUPPLY SYSTEM

Fig. 5. External characteristics of supply system and operation cycle of Gliding Arc reactor
INTEGRATED POWER SUPPLY SYSTEM

Fig. 6. Integrated power supply system
Fig. 7. Power supply system based on transformers with the amorphous limbs with external ignition system
POWER SUPPLY SYSTEM
BASED ON FIVE-LIMBS TRANSFORMER

Fig. 8. Power supply system based on five-limbs transformer
### Working Parameters of the Gliding Arc Plasma Reactor

#### Discharge Chamber Geometry

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Chamber diameter</td>
<td>80 mm</td>
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<tr>
<td>Electrode length</td>
<td>141 mm</td>
</tr>
<tr>
<td>Electrode distance in the ignition area</td>
<td>1 - 6 mm</td>
</tr>
<tr>
<td>Electrode distance in the extinction area</td>
<td>30 - 35 mm</td>
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</table>

#### Gas Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Process gases</td>
<td>Argon, Air, Nitrogen</td>
</tr>
<tr>
<td>Gas flow rates</td>
<td>0.3 – 3.5 m³/h</td>
</tr>
</tbody>
</table>

#### Power Supply System Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-electrode voltage</td>
<td>400 – 1500 V</td>
</tr>
<tr>
<td>Electrode current</td>
<td>1.0 – 3.5 A</td>
</tr>
</tbody>
</table>
Fig. 9. Voltage characteristics for different gases:

- $U_W$ – voltage between working electrodes,
- $U_P$ – transformer primary windings voltage.
Fig. 10. Integrated power supply system
1 – current, 2 – voltage, M – power.

Fig. 11. Power supply system based on transformers with the amorphous limbs
1 – current, 2 – voltage, M – power.
Fig. 12. Power consumption for different gases and flow rates (power supply system based on transformer with amorphous limbs, primary windings voltage: 130 V).
Fig. 13. Power consumption for various argon concentration in working gas (power supply system based on transformer with amorphous limbs, primary windings voltage: 130 V, processing gas: nitrogen).
Fig. 14. Power consumption for various argon concentration in working gas (integrated power supply system, primary windings voltage:230 V, processing gas: nitrogen).
Fig. 15. Power consumption for various argon concentration in working gas (power supply system based on five-limbs transformer, primary windings voltage:110 V, processing gas: nitrogen).
Fig. 16. Discharge current as a function of argon concentration in processing gas for different power supply systems.
Fig. 17. Discharge in the gliding arc plasma reactor supplied from different voltage frequency
Fig. 18. Power consumption for different voltage frequency
CONCLUSION

Power consumption of the gliding arc discharge plasma reactor and its stable operation depends on many factors, among which the most important are:

- power supply system configuration,
- processing gas flow rate,
- processing gas chemical composition.

Trace gases admixtures can essentially influence the plasma chemistry process.

Argon admixture to the processing gas stabilizes the discharge and makes possible to transfer larger power from the power supply system to the discharge.

Correctly selected power supply system decides about plasma chemistry and technological application of this kind of non-thermal non-equilibrium plasma.