Muhammad Nasrullah, Ilaria Schiavi, Elena Reggio, Manuel Lai, Carlo Ferraro, Simona Tusaci

GreenPlasma: a disruptive concept of small-scale end-to-end waste-to-energy system for treating solid waste with plasma pyrolysis technology

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NAXOS 2018 6th International Conference on Sustainable Solid Waste Management, 13 – 16 June 2018
IRIS srl - The company

- SME born in 2012 in Turin, Italy specialised in engineering INNOVATION
- 11 members of staff of which 7 engineers (including a PhD), 2 scientists and an architect
- Background in plasma technology, industrial laser, CNC machining, materials, energy, waste and water management.
- Main field of specialisation: development of small scale innovative solutions for treatment of liquids (water, foodstuff) and solid waste (residual municipal, street and marine litter, hazardous) with recovery of energy and materials.
- Two patents
- H2020 activity:
  - SME Instrument Phase 1 champion with SeaLitterCritters feasibility study (BlueGrowth topic)
  - Winner of an SME Innovation Associate grant (FormulaGP, started Sept 2017 – call INNOSUP02-2016)
  - Technology provider within CLAIM project (BG07-2017)
  - Also active in additive manufacturing and laser welding
The innovation

• ESF funded project that started from proof of concept and arrived at TRL5

• Plasma based thermal treatment that pyrolises waste producing a syngas, i.e. a mixture of combustible gases – mainly hydrogen, carbon monoxide, some methane, some other hydrocarbons and a solid, inert residue recyclable as aggregate for cement/bitumen bound applications

• Designed for small scale, self contained, working in semi-batch/continuous mode with v. quick ramp up and down

• Best application where spare heat can also be exploited: positive energy balance

Applications:

• small isolated communities where waste collection has a significant cost because of inefficiencies of logistics

• wherever small volumes but “difficult” or sudden waste arisings are produced (e.g. boats, ports, WEEE processors, hospitals, tourist resorts etc)

https://youtu.be/Uya2Tjd24yk?t=5m27s
The concept behind it

- Autumn of 2010, Italy: the highest point of a 15 year-long waste management crisis in Naples. Collection stopped because of local energy from waste plant working only at 25% capacity and landfills filling up quicker than expected

- This situation inspired a couple of young Italian entrepreneurs to consider the feasibility of a disruptive solution i.e. equipping each household with a device to deal with their own waste

- High temperature plasma based pyrolysis technology identified as the safest and low impact solution to ensure also local energy recovery

- From proof of concept in the lab to a working prototype of batch system at Technology Readiness Level of 5 (component validated in relevant environment)

- Owing to the participation in project CLAIM, the innovation is now taken forward to TRL 7 (System prototype demonstrated in an operational environment)
The system layout

<table>
<thead>
<tr>
<th>#</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Feeding hopper</td>
</tr>
<tr>
<td>2</td>
<td>Feed rate controller</td>
</tr>
<tr>
<td>3</td>
<td>Shredder</td>
</tr>
<tr>
<td>4</td>
<td>Magnetic separator</td>
</tr>
<tr>
<td>5</td>
<td>Eddy-current separator</td>
</tr>
<tr>
<td>6</td>
<td>Dryer (if required)</td>
</tr>
<tr>
<td>7</td>
<td>Pyrolyzer/reactor</td>
</tr>
<tr>
<td>8</td>
<td>Water scrubber</td>
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<tr>
<td>9</td>
<td>Filter bags</td>
</tr>
<tr>
<td>10</td>
<td>Sulphur removal</td>
</tr>
<tr>
<td>11</td>
<td>Nitrogen removal</td>
</tr>
<tr>
<td>12</td>
<td>Chlorine removal</td>
</tr>
<tr>
<td>13</td>
<td>CHP system</td>
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</tbody>
</table>
The pyrolyzer

- Plasma generated from an electric arc between two electrodes
- Very high temperature (>5000 °C) near plasma arc down to some 1000 °C reactor wall temperature
- Atmospheric pressure, no inert gas shielding
Features of the system and waste streams

- Small scale – 50 kg of waste treatment/12 hours a day (3kWh energy required, almost wholly recovered)
- Use-as-needed working set up
- Developed from commercial components
- Waste streams:
  - Non-recyclable household residual waste
  - Marine litter – e.g. in port and on boat treatment
  - Hazardous waste
  - Clinical waste – in hospitals
  - WEEE – energy production and precious metal recovery
Marine Litter application

• ON BOARD TREATMENT:
  • Volume reduction
  • Energy recovery for the vessel

• AT PORTS:
  • Unrecyclable marine litter
  • Marine waste landed from boats
The system in CLAIM project:

Development of innovative cleaning technologies and approaches, targeting the prevention and in situ management of visible and invisible marine litter in the Mediterranean and Baltic Sea.

Demonstration of the small scale thermal treatment for energy recovery from collected marine litter on board ships and ports.

Optimisation of the energy aspects of the device to be integrated on the skimmer boats servicing booms.

Cost-effectiveness analysis of this marine litter exploitation, business model and business plan development.
Residual municipal waste management for isolated communities

- Case study: A mountain hamlet in the Municipality of Ostana, on the West Italian Alps, some 1600m above sea level.
- An off-grid, autonomous village of about 80 people
- Savings from avoidance of collection: waste disposed of locally with energy recovery

<table>
<thead>
<tr>
<th>CO₂ savings</th>
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<tbody>
<tr>
<td>Diesel savings from reducing waste logistics</td>
</tr>
<tr>
<td>Electricity production from waste replacing fossil fuel</td>
</tr>
</tbody>
</table>
Experimental findings

• Non-recyclable household residual waste for 85-90% wt. converted into syngas (marine litter: min 95% wt.)
• Energy required to process 50 kg of waste in 12 hrs is about 3 kWh
• Very quick conversion of plastics: flash pyrolysis

Ongoing work

• Optimisation of design for continuous or semi-batch working
• Redesign of reactor to improve heat conservation and energy requirement
• Analysis of requirements for commercialisation of system after demonstration
In summary

- Disruptive concept: a truly local but still environmentally sound and safe thermal disposal of waste with energy recovery.

- As waste does not “disappear”, it remains truly the responsibility of the waste producers: an incentive for waste prevention?

- Small plant, with low capex and opex: a good solution for clean up operations alongside waste minimisation measures

- Overall energy neutral (spare heat plus electricity)

- No emissions: syngas + vitrifiable residue (aggregate for bitumen and cement bound applications)

- On the market within 3 years
For the development of the innovation:

ERDF 2007-2014: GreenPlasma project, number FA211-414C, funded by Regione Piemonte

Horizon2020:

«Sea Litter Critters», SME Instrument Ph 1, GA 717863.

«FormulaGP», INNO-SUP2017, GA 739802

«CLAIM», BlueGrowth BG07-2017, GA 774586

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