THESSALONIKI 2021

8TH INTERNATIONAL CONFERENCE ON SUSTAINABLE SOLID WASTE MANAGEMENT

23-26 JUNE 2021, THESSALONIKI, GREECE

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Distribution of energy characteristics in plasma chemical reactor for waste processing

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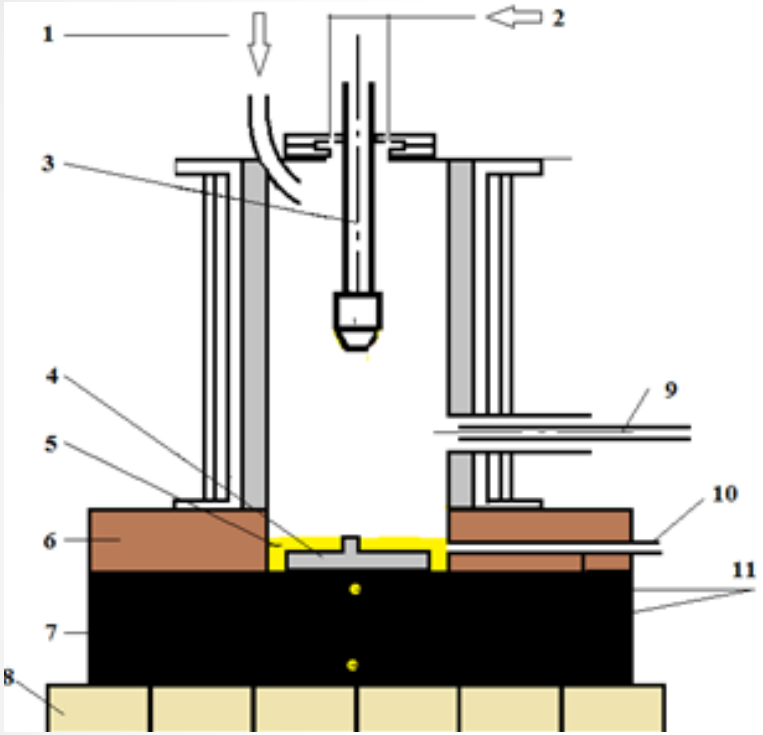
Knowledge of plasma jet characteristics is very important to the areas:

- Plasma spraying;
- Plasma surface treatment;
- Neutralization of hazardous substances and waste;
- Melting of materials at high temperatures;
- Manufacturing of heat resistance fiber;

Experimental setup



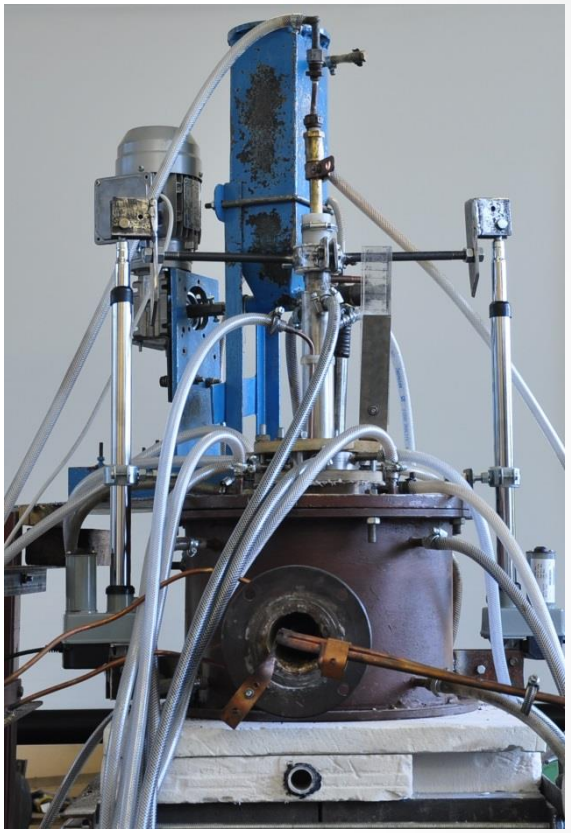


Fig.1. Scheme of plasmachemical reactor. 1 - raw material input into reactor, 2 - protective air supply, 3 - plasma torch, 4 - metal plate, 5 - recyclable waste layer, 6 - high temperature insulation plate, 7 - graphite anode, 8 - insulating base of porous brick, , 9 - cooled probe for gas sample analysis from the reactor, 10 - outlet melt channel, 11 - XA thermocouple.

Experimental setup

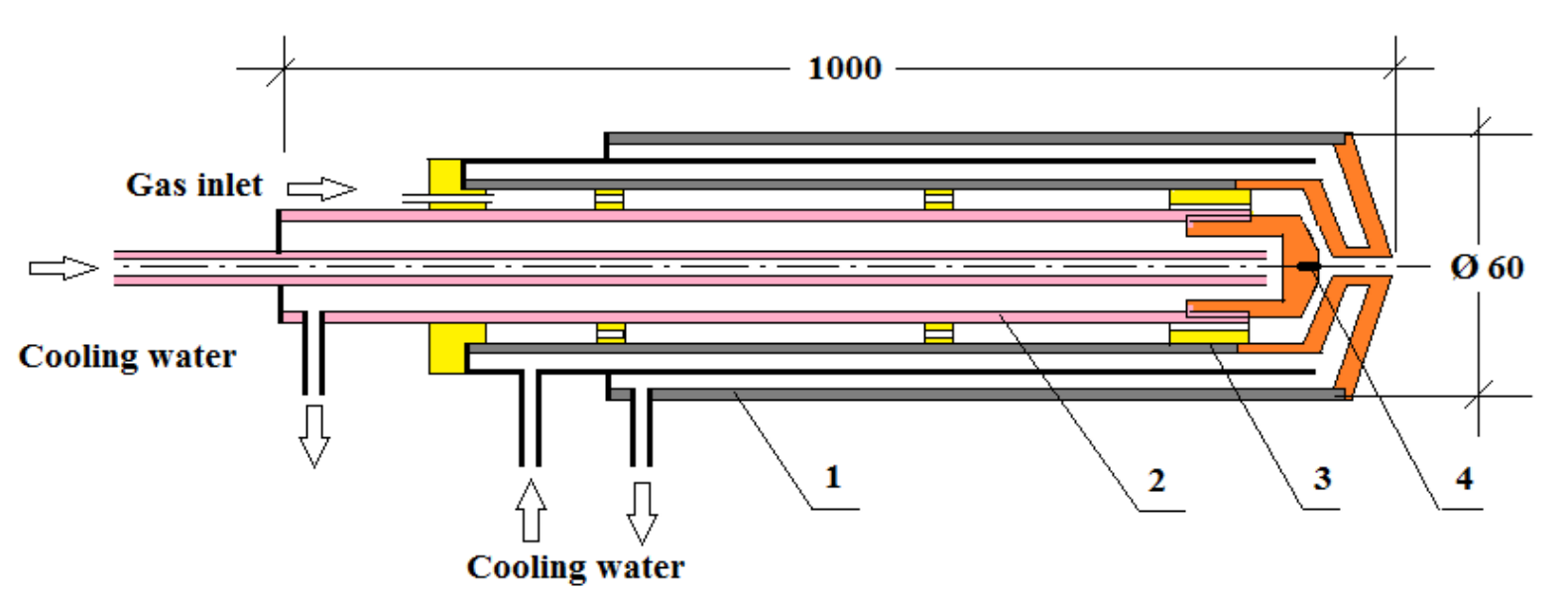


Fig.2. Scheme of the plasma torch. 1 - casing, 2 - cathode holder, 3 - insulating ring for directing gas to the cathode, 4 – cathode.

Recyclable materials

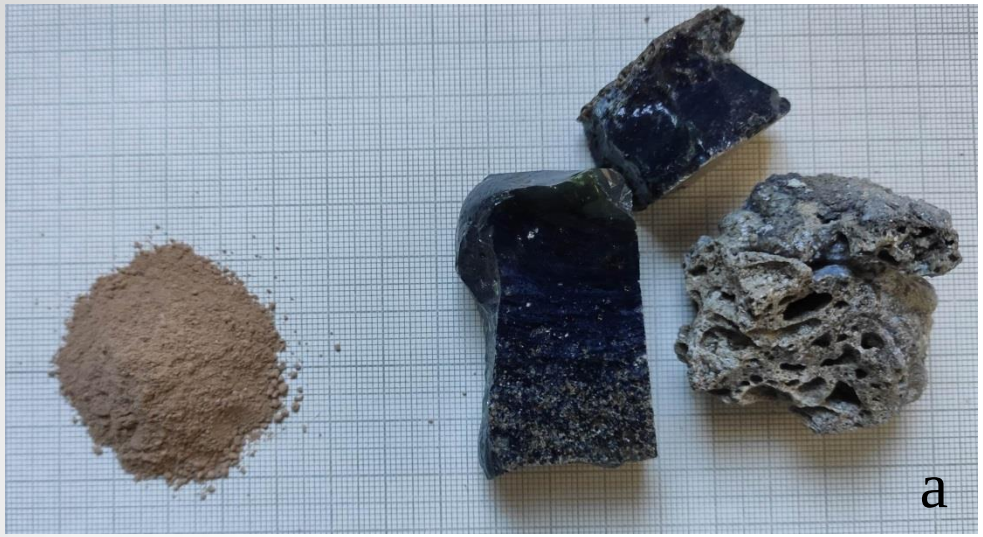


Fig.3. Waste materials used for plasma treatment process and vitrified slag products. a - clay, b - zeolites, c - plasma torch in operation.

Parameters of the plasma torch

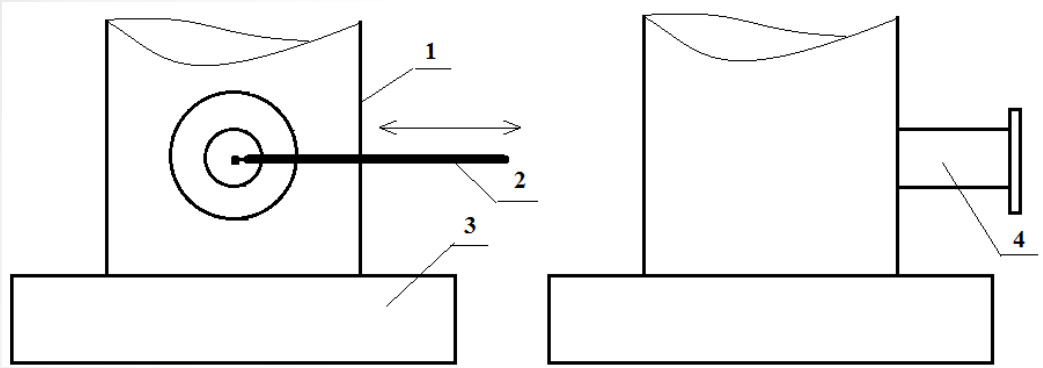


Fig.4. The scheme of outflow gas temperature measuring. 1 - plasma chemical reactor body, 2 – thermocouples, 3 – anode, 4 – gas exit tube.

Table 1. Operating parameters of plasma chemical reactor

Parameter	Operating regime	
	1	2
Arc current *I*, A	160	160
Arc voltage *U*, V	280 – 235	275 – 220
Arc power *P*, kW	44,8 – 37. 6	44 – 35,2
Plasma forming gas flow rate G_1, g/s	0,9	0,9
Additional gas flow rate G_2, g/s	2,63	2,63
Initial distance PT anode – cathode *x*, mm	100 – 50	100 – 50
Initial substance	Zeolite	Clay
Operating time, min.	1 – 40	1 – 40

Thermal characteristics of plasma chemical reactor

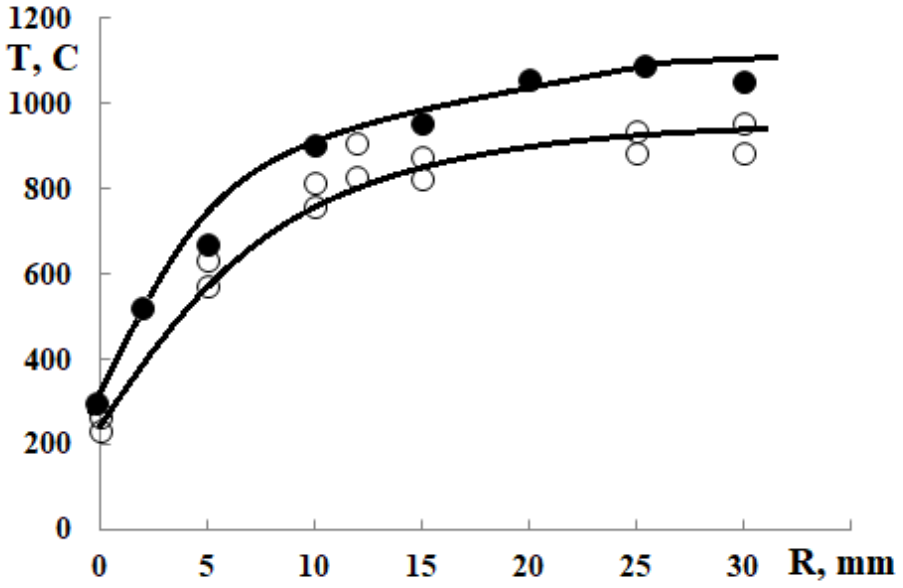


Fig. 9. Radial distribution of gas temperature leaving the plasma chemical reactor. White dots – when working with zeolites, black dots – with clay.

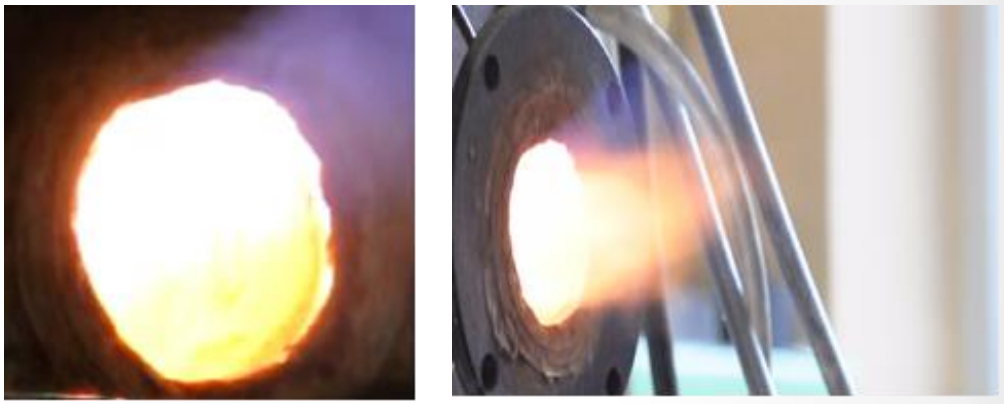
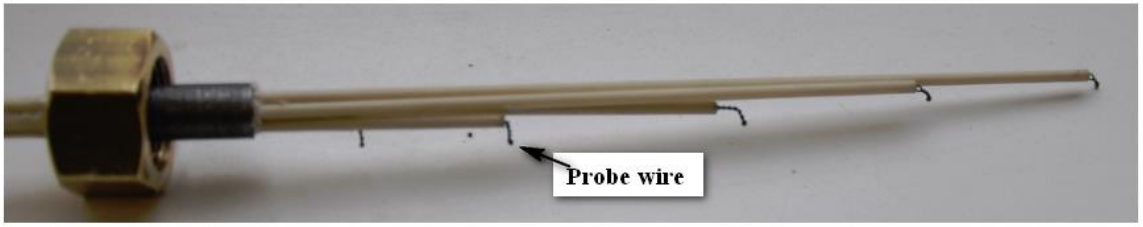


Fig. 10. A view of the plasma chemical reactor exhaust gas glow

Results and discussions

Fig.5. Visualization of the burning electric arc of the plasma torch. 1 - ignition, 2 – after 10 min. of waste recycling.

Characteristics of DC arc



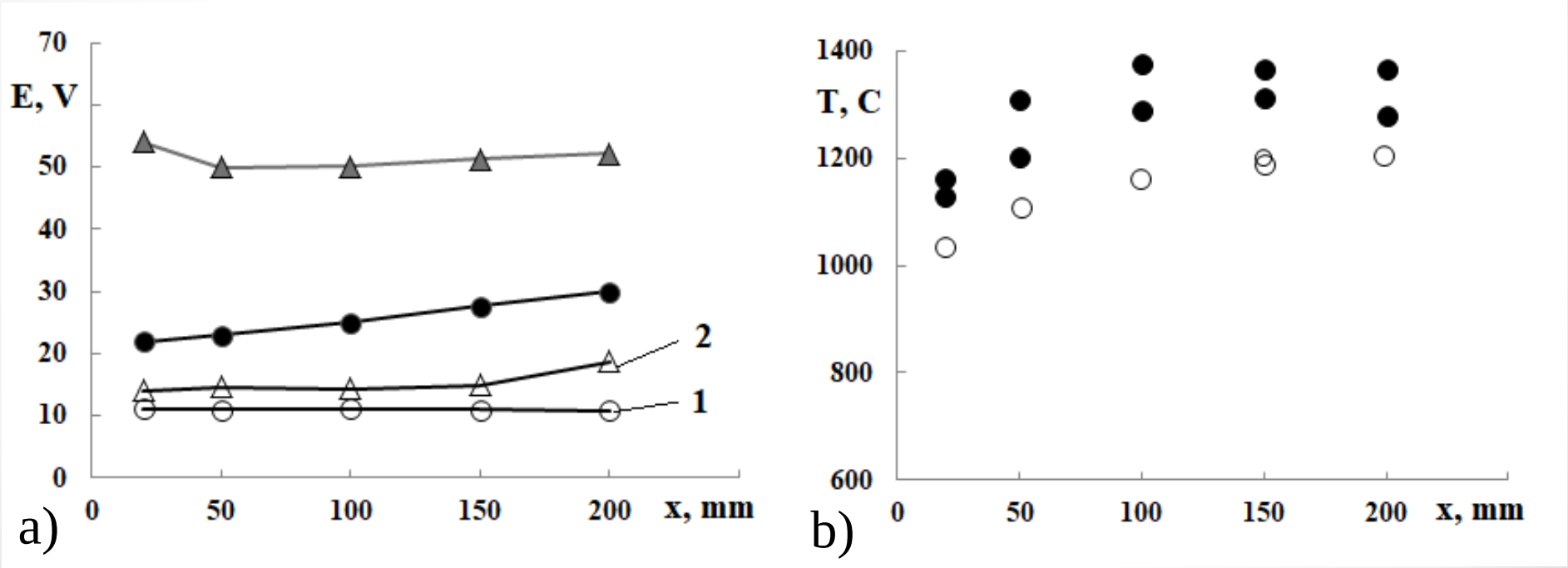


Fig.6. a) Electric field strength and b) axial distribution of temperature in the reactor chamber. 1 – zeolites, 2 – clay. White dots – after starting the reactor, black – after 30 min. of the start.

Characteristics of DC arc

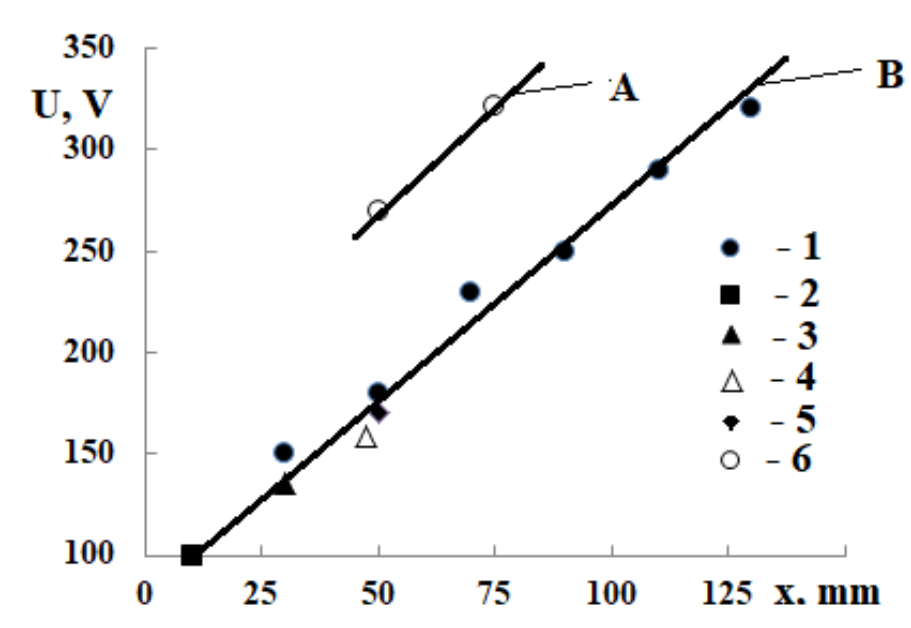


Fig.7. Electric arc voltage dependence from its length. Arc current (A): 1 – 160, 2, 3 – 150, 4 – 200, 5, 6 – 180. Line A – plasma torch operates with waste processing, B – without waste. Air inlet: plasma torch 1 g/s, protecting gas – 2,63g/s.

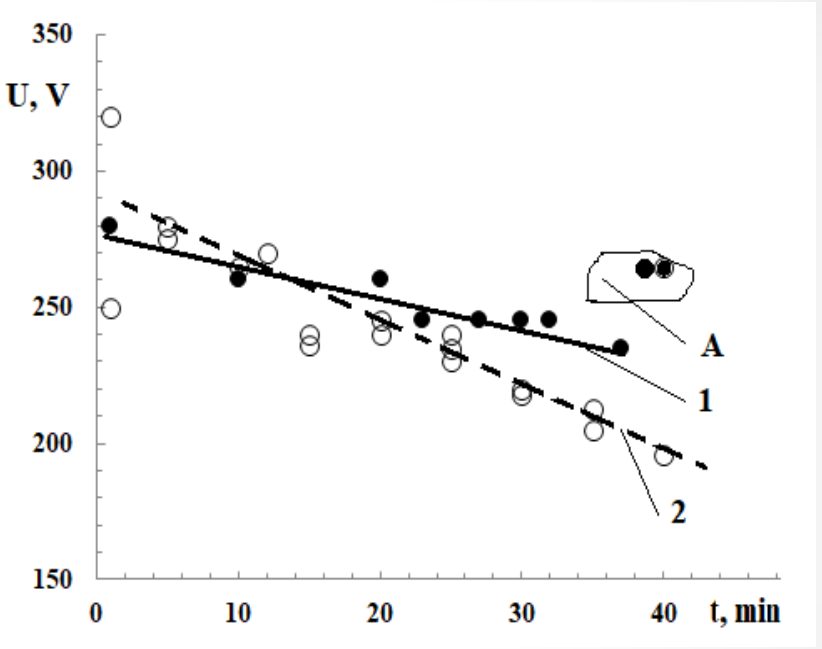


Fig 8. Electric arc voltage dependence from plasma chemical reactor operating time: 1 – recycling zeolites, 2 – recycling clay. A – arc voltage after the melt is released out.

Summary

An experimental plasma chemical reactor for waste treatment has been developed and manufactured. It has been found during experimental investigations that plasma chemical reactor is a good and effective tool for the treatment of solid waste for primary determination of process efficiency and qualify. Experiments show that such a waste treatment system could easily be started and shut down.

Up to 44 kW of power air plasma torch was developed and used for waste treatment in this study. Its electrical and energy, as well as plasma-chemical reactor, characteristics, and its application for zeolites and clay treatment were investigated. It was found that the plasma treatment process converted waste into environmentally friendly melt with much lower volume levels (about 10 – 12 times) than the initial material. The arc power increases with increasing arc current or its length.

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Thank you for the attention

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