ADVANCED TECHNOLOGY OF MUNICIPAL SOLID WASTE CONVERSION FOR A CIRCULAR ECONOMY

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1. Introduction

One of the most important environmental problems of the big urban areas is represented by the large volume of waste that is resulted from different human activities, domestic and industrial. Eurostat shows that in 2016, only in Romania were generated 9012 kg per inhabitant of waste and in the European Union on average 4968 kg per inhabitant of waste. According to the World Bank Group statistics, more than 2000 million tones of waste were generated worldwide in 2018, and it is expected to increase to more than 3.4 billion tones by 2050.

To reduce this alarming amount of municipal solid waste (MSW) that goes to landfills the available solutions are re-use, recycle and usage of waste to energy technologies.

Recycling is an alternative to conventional waste management. It is the process of transforming waste into new materials and objects that can help lower greenhouse gas emissions.

Waste to energy concept is the process of converting waste into energy in the shape of electricity, heat and/or synthetic fuels.

2. The principal thermochemical technologies for treating MSW

2.1. Incineration and co-processing

Incineration is a combustion process that transforms waste into ash, exhaust gases and heat, reducing the initial volume to almost 5%. Incineration sterilizes the dangerous wastes, generating at the same time thermal energy that can be in the form of heat (hot water or steam), electricity or both. In table 1 are presented the advantages and disadvantages of the process of incineration of MSW.

Table 1. Advantages and disadvantages of incineration.

Advantages	Disadvantages
All municipal solid waste, as well as some hazardous and industrial waste, can be disposed of, unsorted;	Substantial financial investments and a long time recover of the initial financing, generating a long-term lock-in;
Municipal solid waste volume is reduced to 5%, and is mainly composed of ash which can be recycled as a filler in road construction;	A large quantity of toxic fly ash and exhaust gas, which must be disposed of by storage at a suitable warehouse (approximately 2-5% of the weight of the input waste);
Well-known process, installed worldwide, with high availability and stable operating conditions;	NOx and other gases and small particles;
If cogeneration of heat and electricity is used, or only heat results in a high-efficiency energy recovery up to 85%;	Bottom Ash with medium toxicity with concerns of releasing heavy metals to the environment;
Ash and other waste materials resulted are inert;	
By incinerating waste, the release of methane is prevented.	

2.2. Pyrolysis

Pyrolysis is a thermal method of pre-treatment, which can be applied to convert organic waste into a medium calorific gas, into liquid and a carbonized fraction aiming at the separation or binding of chemical compounds to reduce emissions and leachate. In table 2 are presented the advantages and disadvantages of the process of pyrolisys.

Table 2. Advantages and disadvantages of pyrolysis.

Advantages	Disadvantages
Better retention of heavy metals in carbonized residues;	Waste must be sorted and shredded before pyrolysis treatment;
A smaller quantity of emission gases than in incineration;	Resulted oils and tars could have dangerous and carcinogenic elements;
Hydrochloric acid can be retained in or distilled from the solid residue;	Relative high cost;
All resulted residues are inert.	Fuel supply is required at least during start-up.

2.3. Plasma gasification

Gasification is a method of heat treatment, which can be applied to convert organic waste into a medium calorific gas, recyclable products, and residues. Gasification is normally followed by combustion of the gases produced, in a furnace and internal combustion engines or simple gas turbines after a proper purification of the gas produced. The principal difference between gasification and pyrolysis is that by gasification the fixed carbon is also gasified. For commercial use, the available gasification technologies are counter-current fixed bed, co-current fixed bed, fluidized bed, entrained flow, plasma, and free radical (figure 1).

Plasma gasification is a thermal process that uses plasma to transform organic compounds into synthesis gas (syngas) which mainly contains H2, CO, and CH4, that can be used for direct combustion or raw material.

Plasma, also known as the fourth state of matter, is formed by a strong electric current that passes through a gas who is ionized and converts organic compounds into syngas, with slag as a byproduct. Plasma is formed by the interaction between the electric current and the gas which is ionized and causes the temperature of the gas to increase significantly to more than 5500°C, almost as hot as the sun's surface. Plasma torches can be supplied with various gases, air, oxygen, nitrogen, argon, and others. This flexibility allows the plasma unit to be adapted for various applications. Plasma gasification technology is a highly efficient process of heating the waste that is introduced in the plasma reactor at an extremely high temperature until they dissociate resulting in primarily chemical elements, the equipment can operate with minimal maintenance in a different industrial environment.

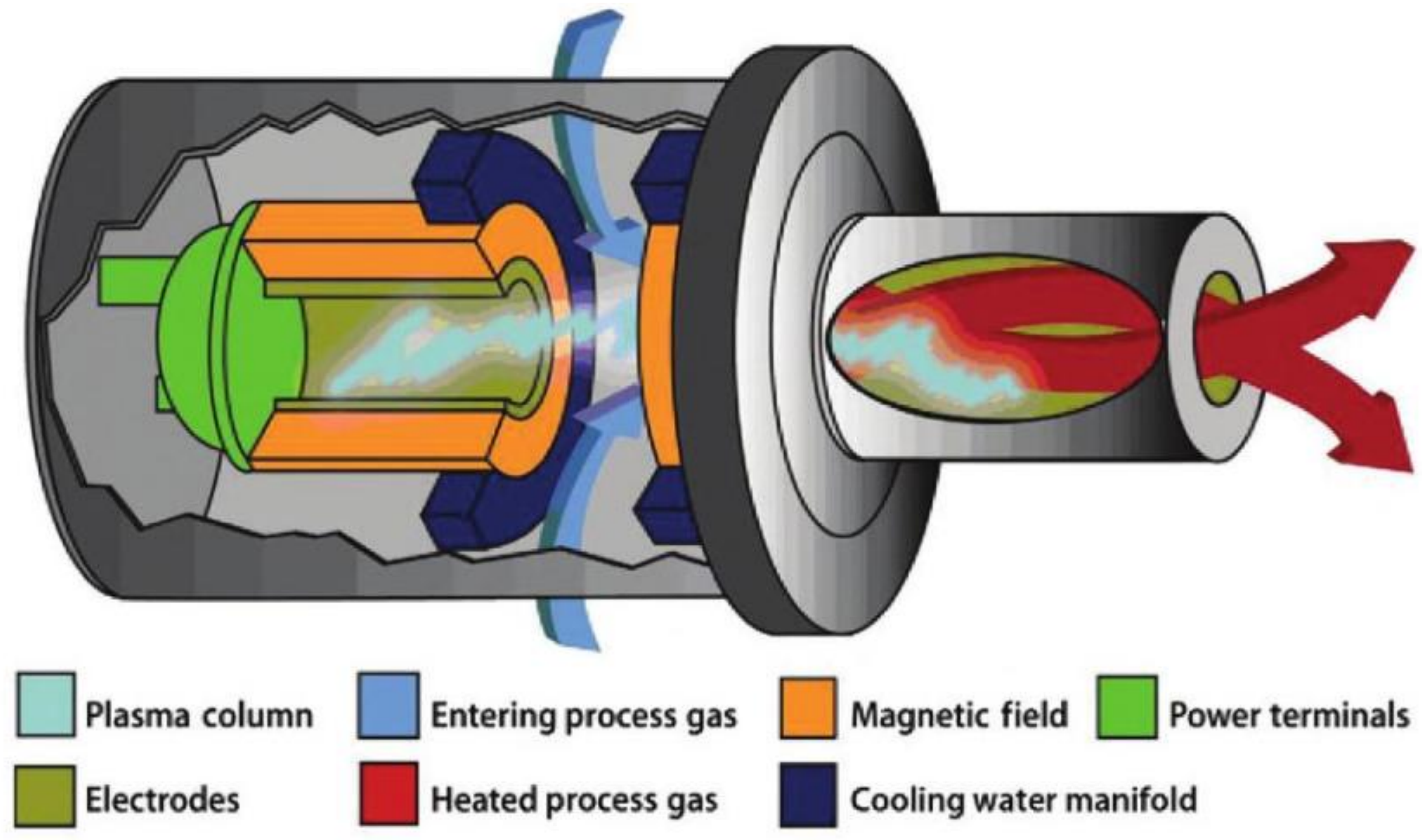

Figure 1. Plasma torch schematic.

The plasma torches offer a high level of flexibility for plasma reactors, as it allows temperature control, regardless of the flow of waste or oxygen in this process.

The main benefits of the plasma gasification are:

• High reliability – more than 500,000 hours of continuous operation in commercial use; • Available in a wide range of powers input, from 80 to 2,400 kW; • Input power can be adjusted to meet the process requirements; • Long electrode life; • Auto stabilization and non-transferred arc; • Process gases can be air, oxygen, nitrogen, etc.;

• Long-life electrode; • The syngas with very low in NOx, SOx, dioxins, and furans;

• High reliability - plasma torches have no moving parts, consumables are quickly replaced by maintenance personnel

3. Circular economy

It is known that the current economy consumes a significant amount of raw materials and non-renewable energy. Now, when humanity's negative influence on the environment is intensified, the implementation of an efficient circular economy is a highly debated topic internationally. The circular economy focuses on eliminating waste by creating a closed-loop system that involves reusing, refurbishing, recycling, reducing the consumption of valuable resources and the production of waste, pollution and greenhouse gases such as CO2, NOx, SOx, CH4, and others (figure 2).

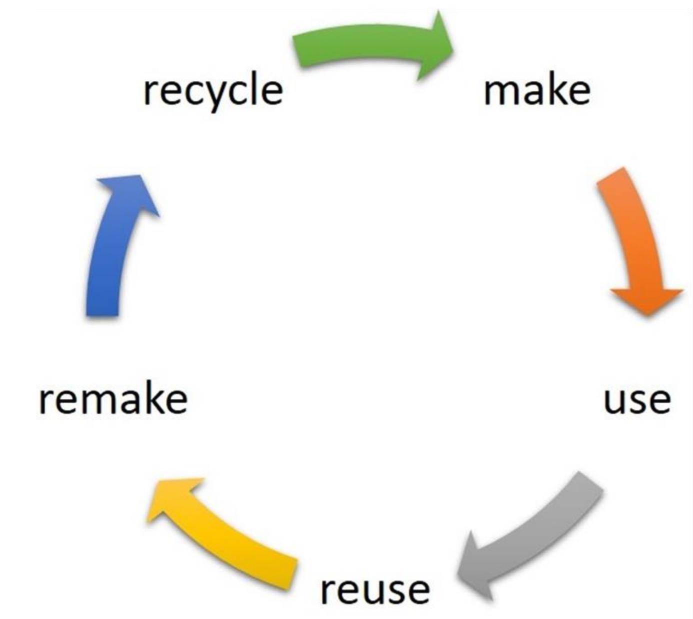

Figure 2. Circular economy (closed-loop system).

From an economic point of view, how the regulatory framework and its enforcement are applied can be the principal hindrance. On the other hand, the implementation of local economic tools has important premises as good management skills, innovation, and last but not least, environmental awareness. The instruments at the local level can take the form of tax modulation or taxes, waste pricing, refunds, and product levies.

4. Conclusions

Considering the applications of plasma conversion for waste to value processing, the potential environmental benefits could be enormous. Public and/or private companies could build waste treatment units having substantial financial benefits and also improving the actual waste collection and treating infrastructure.

Plasma conversion systems are the future in waste management because they have a considerable low impact on the environment, having the lowest emissions from all waste treatment technologies available at the moment. Another important aspect of this technology is that it can treat medical and hazardous waste, resulting in syngas, metals and inert slag.

References

The references of this article are 40, but in this poster are just the most important 5 titles:
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