PlasTEP

plasma for environment protection

Criteria of Plasma Technologies Appraisal

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1 Plasma in environmental protection

The application of non-thermal plasma in environmental protection processes shows a great potential. It is widely used in sterilisation and disinfection due to lack of side effects and waste products, relative environment friendly, ability of conduct plasma-chemical treatment at an atmospheric pressure and ambient temperatures. One of the most popular practices is application of ozone (which is generated in plasma reactor) in the drinking water treatment technology. Plasma technologies applications in environmental protection may be divided into few groups:

- Sterilisation of air, water, soil, surface etc.
- Removal of sulphur and nitrogen oxides (SO_x and NO_x) as well as volatile organic compounds (VOCs) from exhaust gases from the combustion of fossil fuels, waste incineration etc.
- Removal of VOCs that generated in the process of painting, varnishing and other chemical processes
- Odours removal
- Water treatment

The above given processes do not cover all the possible applications due to variety of plasma technologies and their adjustability to different conditions and tasks.

Plasma for environmental purposes can be generally generated by three ways:

- by the injection of a high energy electron beam,
- by applying an electric field to a neutral gas (various types of gas discharges),
- by use of microwaves.

However even in these three categories there are numerous methods of process realization e.g. gas discharges may be generated by DBD discharge, corona discharge, hollow cathode discharges etc. All the methods have their advantages and disadvantages e.g. electron beam plasma generation is usually more energy effective, but DBD process allows for construction of more compact devices.

The first stage of implementation of pollution control technology in industry is careful selection of the most suitable technology. Such process is unique for each case and every time different set of parameters have to be considered. However the core of the selection criteria is common for all plasma based emission control technologies. Beneath the main appraisal criteria are suggested and briefly described.

2 Main appraisal criteria

The criteria of plasma technologies appraisal shall be divided into three main groups such as:

- Technical criteria
- Economical criteria
- Other criteria

Although some criteria are to be applied to any case as e.g. removal efficiency, most of them can be analysed for certain case.

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3 Technical criteria

The following technical criteria shall be mentioned as important for plasma technologies appraisal:

- Effectiveness

  Effectiveness is defined as the concentration of removed pollutant according to inlet concentration of this substance:

  $$\eta_X\,(\%) = (c[X_{Inlet}] - c[X_{Exhaust}]) / c[X_{Inlet}] \times 100$$

  This is one of the most important parameters. The effectiveness of the pollutants removal has to be at least high enough to fulfil actual emission standard according to certain compound. However due to emission standards progress the efficiency of the technology shall be higher.

- Reliability

  Reliability is the ability of the plant for operation without a malfunction. The reliability is defined as number of hours of plant operation in the year or percentage of the annual operation time. Standard reliability of the pollution control facilities in energy generation sector is at least 95% (8322 hr/year).

- Energy consumption

  As plasma is generated with use of great amount of electric energy, energy consumption is one of the most important parameters both from technical and economical point of view. Energy consumption may be given either as total energy consumption (kW) or as unit energy consumption (kJ/tone of pollutant removed, W/m^3 of treated gas).

  For comparison it is worth to underline, that in conventional flue gas treatment facilities 2 to 3 % of energy generated in power plants is consumed for flue gas treatment.

- Substrates and products

  Specification and description of main substrates being used in the process as well as generated products is crucial for the technology characterization and further estimation of other criteria (cost, logistics issues etc.).

- Maximal size of plant

  Plasma emission control technologies are dedicated mostly for small and medium size industrial plants. Therefore the maximal flue gas flow rate shall be specified.

- Flue gas parameters range

  Plasma emission control methods are very flexible and may be applied for treatment of flue gas with high variety of inlet flue gas parameters. However every boundary parameter (like temperature, inlet concentration etc.) limiting the application of the certain technology must be specified.

- Space requirements

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Space requirements are especially important in the case of retrofitting, where new facility must be placed between existing ones. The dimensions of the space necessary for implementation of certain plasma technology shall be specified.

4 Economical criteria

The following economical criteria shall be taken into consideration during appraisal of plasma emission control technologies:

- Total investment cost

  Total investment cost covers such elements as supplies (materials and equipment cost), labour cost (civil works and assembling) and other (licenses, trainings, commissioning etc.). Total investment cost strongly depends on the size of the plant and local conditions, therefore it may be used for certain case.

- Total operational cost

  Total operational costs contain both annual expenditures and incomes if any. The expenditures shall cover such elements as energy consumption, basic raw materials, auxiliary raw materials, maintenance and spare parts and direct labour costs. The incomes may be regarded as byproduct selling incomes as well as saved penalties for emission.

- Unit investment/operational cost

  Both investment an operational cost strongly depends on the plant size. Therefore it is better to present them as unit cost in USD/kW of produced power or USD/t of removed pollutant, that can be used for comparisons between different methods and facilities. However scale effect is still strong in these indicators, especially in the case of small and medium size installations.

- Market status of byproduct

  Any byproducts obtained in the gas treatment process might be regarded as wastes or marketable products. If the byproduct may be used e.g. as fertilizer the possibility of such use as well as its market status (market absorbability, market price etc.) shall be described.

5 Other criteria

Beside technical and economical criteria, also other criteria shall be taken into consideration. These criteria may complement technical and economical criteria as well as influence on them.

- Investment risk

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Investment risk is one of the most important factors for decision makers. Every new technology including plasma pollution control technologies are regarded as high risk investments during first implementations. The investment risk depends on the maturity of the technology as well as on the warranties offered by plant supplier. Therefore high number of reference installations and strong main contractor may be an important factor for decision makers.

- Logistics issues

  Logistics issues as transport issues, localization of substrates manufacturing plants or byproduct receiver may indirect influence investment and operational costs. Such issues shall be described according to planned localization.

- Media availability

  Media availability is an important factor influencing both technological issues (necessary new media supply facilities) and economical issues. Media requirements and availability shall be analysed and described.

6 Summary

Three types of criteria of plasma pollution control technologies appraisal may be distinguished: technical, economical and other. The criteria are not completely independent, but partially interact with each other.
The main criteria for plasma technology appraisal were suggested. The list doesn't cover all possible criteria and, depending on certain case, this list may be modified. The final list of technology criteria appraisal shall be decided with regard to local conditions.

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