NEW TECHNOLOGIES FOR HOSPITAL WASTES TREATMENT

ION V. ION, PARASCHIV SPIRU, PARASCHIV SIMONA LIZICA

"Dunărea de Jos" University of Galați

Abstract: Medical wastes due to the hazards to the human health and to the environment require special handling, treatment and disposal, usually according to specific regulations and guidelines. Because of financial difficulties, many hospitals have tried to find some cost-effective treatment and disposal means of their waste. In this paper are describes new methods for treatment of medical wastes.

Keywords: Medical waste, Incineration, Pyrolysis, Waste classification, Cost, Emissions

1. INTRODUCTION

Medical waste is defined as any solid waste that is generated in the diagnosis, treatment or immunization of human beings or animals, in related research, biological production or testing. It can include general refuse wastes, like paper, flowers, food, plastic cups, as well as laboratory and pharmaceutical chemicals (alcohols, disinfectants etc.), and infectious wastes like contaminated sharps, human blood products, tissues and body parts, cultures etc [1]. Medical wastes are classified according to their source, typology and risk factors associated with their handling, storage and ultimate disposal. The Environmental European Agency classifies the medical waste into two types: specific hospital waste and other hospital waste [1]. In United States of America are identified three types: red bag, pathological and general [2]. In most instances the classification of medical waste is made considering two types: general waste and special waste. General waste is not defined as hazardous or potentially dangerous wastes and therefore it does not require special handling, treatment and disposal. It is considered similar to municipal waste. Special waste are materials considered to be potential health hazards, requiring special handling, treatment and disposal and can include chemical waste, infectious waste and radioactive waste. The main treatment techniques of special waste are incineration and steam sterilization. Due to severe regulations concerning on-site incineration the off-site treatment and disposal has been used. Treatment by incineration and disposal of the resultant ash by landfilling as most employed treatment method has the following advantages: putrefaction prevention and sterilization of pathological or anatomic wastes, volume reduction (by about 90%) and waste heat recovery. The main types of the utilized incinerators are: controlled air (the most used incinerators), excess air and rotary kiln. Using a proper operation and maintenance of incinerators the ashes resulted can be innocuous and can be disposal by landfill. The main disadvantages of medical waste incineration are the emission of hazardous pollutants such as dioxins, furans, fly ash and the generation of hazardous solid waste from gas treatment equipment (electrostatic precipitators, fabric filter). Special medical waste includes significant quantities of materials containing chlorine, such as polyvinyl chloride (PVC) or disinfectants and their incineration can produce dioxins and furans. Fly ash (particulate matter carried over from the furnace and removed from the flue gas) and solid residue from gas treatment equipment are considered hazardous due to their content of heavy metals (Cd, Cr, Pb, Zn) and soluble salts. Land disposal of these residues can lead to environmental impacts associated to the leaching of pollutants to surface and ground water. The management option of these residues most widely used is still landfilling even some alternatives have been developed like incorporating in roadbase, masonry bricks and ceramic products [3]. The incineration of medical waste without control of atmospheric pollutants does not obey the legal emission limits even when correct practices of operation are used (controlled feeding rate, controlled combustion air, high temperatures, proper turbulence and residence time) [2].

2. ALTERNATIVES FOR TREATMENT AND DISPOSAL OF MEDICAL WASTE

Yet, all methods of medical waste combustion have some disadvantages. First of all, the formation and removal into the atmosphere of large amount of toxic waste: such as ash containing heavy metals, soot, hydrogen monoxide, sulfur and nitrogen oxides, chlorine compounds and dioxins. Ash usually contains the unburned hydrogen and polyaromatic agents. Combustion of toxic waste using existing technologies requires application of costly purification in order to meet environmental standards. It also rather increases operation expenses [6].

Because the public is fearful of potential exposure to pollutants produced from incineration of medical waste and many hospitals or health care facilities have faced financial difficulties, many new techniques are now being developing like pyrolysis and gasification, microwaving, autoclaving, steam sterilization, steam detoxification, radiowaving and electron-beam irradiation.

A solution of ecological and energy problems is the use of the pyrolysis for medical waste treatment. Pyrolysis is a process that is less regressive than incineration and recovers much of the chemical energy. The pyrolysis process or thermal depolymerization consists of heating organic compounds to 500-1000°C under non-oxidation conditions, breaking chemical bonds of compounds, and turning macromolecular compounds into small molecular weight compounds. Long-chain organic material disintegrates when exposed to a high-temperature thermal flux according to the following equation:

$$\text{Polymeric material} \oplus \text{Heat flux} \Rightarrow \text{aA(gas)} + \text{bB(Liquid)} + \text{cC(solid)}$$

The resulting gas includes CO_2, CO, H_2, CH_4, and various saturated and unsaturated hydrocarbons. The liquid contains a variety of chemical compounds, and the liquid ranges from a tar substance to a light water-soluble distillate. The solid is primarily a solid char. These processes are endothermic and thus require the feed of a lot of heat into the furnace, thereby increasing power in the power sources. The recuperation of energy is possible only due to combustion of obtained pyrolytic gas (syn-gas) [6].

The process of Thermoselect S.A. technology is gasification of solid waste at 1200°C [4]. To prevent re-formation of organic compounds, direct shock cooling of the synthetic gas from 1200°C to below 80°C is employed to clean the gas. By this method, dioxins do not get reduced and the hazard factor is eliminated. The solid residue produced is less than 10% of the initial solid waste and its main components are ash, metals, glass. Glass and metals can be recovered and recycled.

Properly design and operated devices for waste pyrolysis and gasification do not pose serious threats to the environment. Emissions control is easier in pyrolysis than in incineration due to reduced oxygen content, lower temperature and reduced air flow rate.

The major technical problems of Thermoselect S.A. technology are the high temperature burning which consumes high temperature energy resources and fast cooling down which increases the operation difficulty.

It seems that plasma technologies are more economical in comparison with other methods (table 1) [6]. The plasma technology is the process of high temperature waste mineralization resulting from the effect of isothermal plasma obtained due to plasma-formation from the gas flowing through the electric arc. Plasma technologies allow realizing all the benefits of the technology:

- higher hydrogen conversion (due to higher process temperature) into CO and syn-gas generation thus higher efficiency of initial product treatment into syn-gas;
- increased rate of the chemical processes in the reactor at the expense of higher thermal and chemical activity of low temperature plasma owing to higher energy density;
- much less formation of toxic agents resulting from the pyrolysis due to physical-chemical processes (except from mentioned above, radiation, active radicals and ions) and the option of the line control.

The use of thermal plasma reactors offers a set of unique advantages [5, 6]:

- the possibility of temperature control in the basic reactor ranging from 1 000 to 10 000 K;
- significant waste destruction with the simultaneous decrease of the exhaust gas volume. Furthermore the disinfection of waste is achieved;
- much lower weight and dimensions of the reactor and the whole installation compared with furnace units;
- the possibility of complete automatic control of the process;

- minimal time and funds required for repair of high temperature plasma sources.

The major disadvantage, especially with respect to the economic point of view, lies in the use of electrical power as the energy source. Furthermore, a large number of process parameters have to be controlled, and in many cases the processes happen in a split second, which requires a high level of automation.

Currently, the industrial technologies of medical waste treatment using the plasma pyrolysis can be divided into three groups, each of them having its advantages and disadvantages [5]:

- chamber reactor with a molten bed;
- reactor with free arcs;
- shaft reactor.

In the long-term view, this technology will provide on-site treatment of medical waste, with the benefit of saving costs in the handling and conditioning of waste generated. The new system will meet the general demand of 3% total organic carbon (TOC) for thermally treated waste, as well as reduce the amount of waste going to landfill and emissions of volatile components to the atmosphere [5].

Table 1. Economical indexes of various waste treatment methods [6].

Method of treatment	Cost of treatment, Euro/t	
	Min	Max
Landfill	105	160
Incineration	100	140
Pyrolysis, thermolysis	90	150
Plasma method without syn-gas production	100	120
Plasma method with syn-gas production	70	80

Currently, microwaving and autoclaving have been considered as positive alternative treatment methods to incineration [7]. Microwaving might be economically competitive with incineration and applicable to continuous-or batch operation. Wastes are microwaved for 30 min in a preheated treatment chamber and then held at minimum temperature of 93-95°C to ensure proper disinfection. Microwaving is not sufficient for sterilization temperature above 120°C. By microwaving, spores are activated and some spores may survive.

Autoclaving which sometimes is referred as steam sterilization consists of introduction of steam, dry heat or radiation into a tightly sealed chamber and wastes in the chamber are maintained under temperature between 121 and 163°C to destroy the spores. This treatment method is widely used for recyclable items such as paper, plastics and lab trash. Microwaving and autoclaving are generally not applicable for pathological, radioactive, laboratory and chemotherapy wastes [7].

Because of the misclassification of wastes and application of improper disposal method the total costs of medical waste treatment and disposal are increasing. To minimize these costs, every hospital should employ a proper classification system and utilize different treatment and disposal methods according to the classification of waste type. Also, a recycling program of medical plastic waste should be developed, because the plastic content of medical waste is high and plastic wastes require significant costs for transportation to disposal facility. Using effective treatment and disposal methods based on the classification of medical wastes, the emissions of hazardous pollutants, such as dioxins and furans could be much reduced.

3. CONCLUSIONS

To a cost-effective management of their medical waste, the hospitals should develop a proper program which implies the applying of a proper classification system, a recycling program of medical plastic wastes and applying of the most-effective treatment and disposal methods suitable for each properly-classified waste type.

The most suitable method for treatment of special medical waste seems to be pyrolysis (thermolysa) or plasma pyrolysis.

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