Medical Waste Management in Covid 19 era

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Abstract – *Application of Instrumentation will have a greater impact in solving most of the problems arising during and in the post covid era. Current scenario of pandemic demands for a faster, efficient management of medical waste. For countries struggling to deal with the pandemic and the economic crisis thereupon, it is difficult to bring in newer technologies. In this context, it is better to adopt the instrumentation involved in Controlled pyrolysis for Medical waste disposal.*

Key Words: **COVID 19, Medical waste, controlled pyrolysis, PID controller, Instrumentation**

1. INTRODUCTION

The World is under COVID 19 pandemic. Time proves we are fighting against our own shadow. The entire mankind is trying hard to contain the unknown enemy. Biologists, health officials and governments across the globe are trying hard to contain and mute the effects of Covid 19. With the increase of patients daily, health workers are toiling with various strategies and protocols. They have to fight the disease inflicted and ensure that this virus is not transmitted to new human beings. The other side of the portray is the accumulating medical waste. In the coming days, the demand for the sustainable medical waste management will certainly rise. [3]

1.1 Warning Bell

Wuhan, the major transit hub of China reported the first case of Covid 19 pandemic in early January 2020.The impact of the epidemic is well demonstrated by the medical waste growth from 40 ton per day volume to 240 ton per day volume. Each country will certainly face an equal challenge in the medical waste management. The medical waste management of a country depends on several factors like policy making and enforcement, existing collection, transportation, management facilities, medical waste treatment methods and existing excess capacity. [4]

1.2 Principal Methods

Principal methods of medical waste management include incineration, autoclaving, mechanical/chemical disinfection, microwave, irradiation and vitrification. The treated waste, if sufficiently sterile, can generally be disposed with waste in a sanitary landfill, or in some cases discharged into the sewer system. In some countries, treatment of medical waste is primarily performed on-site at hospitals in dedicated medical waste facilities. To ensure that the treatment method provides the proper environment for the destruction of microbes, test indicators for bacterial spores measure the treatment effectiveness. Microbiological spores are among the most difficult of biologicals to destroy, so when the indicator package cannot be cultured after treatment, the waste is considered properly treated. [1]

1.3 Incineration to Vitrification

Incineration is the controlled burning of the medical waste in a dedicated incinerator. Waste with heating value over 3500 kcal/kg is processed in a pyrolysis unit while lower heating value waste is burned in a single-chamber incinerator. Waste is typically heterogeneous, and if the combustible fraction is below 60 percent, it may not be acceptable for incineration. Overly wet waste (over 30 percent water by weight) is probably not good for incineration either as it will require excessive quantities of assist gas/fuel. Incineration is an old technology and is widely used for all sorts of waste. Individual buildings had their own waste incinerators in many cases. Incinerators have a bad reputation because of the air pollution they create and because the bottom ash, or clinker, is hard to keep under control. Incineration is often the best technology for treating medical waste. It can eliminate pathogens - even hard-to-kill bacterial spores - and can reduce the volume and mass of waste that goes to landfills considerably. Incineration can break down and render harmless hazardous organic chemicals. With proper technology, little acid gas is released to the atmosphere. Incineration requires no pretreatment. Because most medical waste can be incinerated, the waste does not always require sorting or separation prior to treatment. Incineration has the benefit of reducing the volume of the waste by 80 percent or more. The resulting incinerated waste can be disposed of in traditional methods, such as landfilling. The downside of incineration is potential pollution from emissions generated during incineration. The largest concern associated with incineration is air pollution from emissions. Studies reveal that at least 20% of medical waste is plastic. Dioxins and furans can be produced when these plastics burn. Another concern is incinerator ash. As incinerators are designed or retrofitted with pollution prevention equipment, more of the potentially toxic chemicals that previously ended up in emissions now remain in the ash. It is absolutely true that the incineration can be a dirty process if not controlled adequately or if the process has not been designed correctly.

Autoclaves are closed chambers that apply heat and sometimes pressure and steam, over a period of time to sterilize medical equipment. Autoclaves have been used for a century to sterilize medical instruments for re-use. Surgical knives and clamps, for instance, are put in autoclaves for sterilization. For medical waste that will be disposed of, autoclaves can be used as heat treatment processing units to destroy microorganisms before disposal in a traditional landfill or further treatment. Autoclaves are a batch process, not a continuous one. One problem with autoclaves is that the process can aerosolize chemicals present in the waste, leading to the potential for release of materials you would prefer to not release. This can pose a hazard to human operators and to some extent the environment.

Mechanical treatment in waste management includes granulate, pulverizes, shreds, grinds, mixes, agitation, and crushing. This can reduce the bulk volume of the waste by 60 percent or more. Waste can be moved through the processing facility with augers, conveyor belts, and other material handling systems. Mechanical treatment does not kill pathogens or disinfect equipment, but it can reduce waste volume in preparation of further treatment or disposal. Equipment involved can include crushers and milling machines, Mechanical shattering or splintering of waste can also alter its appearance, which can be useful in lessening the psychological impact of the waste on human observers.

In addition to being able to reduce bulk waste volume, mechanical systems can increase the surface area of the solid pieces before subsequent chemical or heat treatment. Mechanical systems can also be an operational headache - more things to go wrong and more things to be decontaminated. Further, mashing or shredding of solid waste can generate dust. If this dust becomes airborne, it can be a workplace hazard and a threat to the environment. That’s why mechanical equipment is often kept in a closed room or under a hood, at slightly lower than ambient air pressure.

Chemical disinfection, primarily through the use of chlorine compounds, kills microorganisms in medical waste and can often oxidize hazardous chemical constituents. Chlorine bleach has been used for disinfecting processes for years Ethylene oxide treatment is used more often to sterilize equipment that will be reused. It is too expensive to use on equipment or waste that will be sent to a landfill. EtO gas infiltrates packages as well as products themselves to kill microorganisms that are left during production or packaging processes.

Microwave radiation is used to treat wastewater sludge and as a heat source to treat medical waste. Microwave treatment units can be either on-site installations or mobile treatment vehicles. The processing usually includes front-end shredding of the waste, both to increase the efficacy of the microwave treatment and to reduce the volume of the end waste for disposal. If the waste is dry, water is introduced and the wet waste is introduced to the microwave chamber. Microwave disinfection works only when there is water in the waste because the radiation directly works on the water, not the solid components of the waste.

Irradiation is another method which disinfects waste by exposing it to gamma rays that are fatal to bacteria. A radioactive isotope of cobalt is employed. This is basically the same radiation source used for radiation treatment of cancer. Irradiation does not change the appearance of the waste. So process designers often install mechanical grinding or shredding upstream.

Although it is rarely used, vitrification can be an effective treatment for medical waste. The solid waste is mixed in when glass is formed (vitrification means production of glass). The high temperatures kill pathogens and some combustible material may burn or pyrolyze, resulting in an off-gas. Remaining material is encapsulated in glass, which has a very low diffusivity. There is little danger of hazardous materials leaching out of glass in significant quantities. The vitrified waste can therefore be put in a landfill with confidence. [2]

2. Demand for appropriate technology for medical waste disposal

The demand for an appropriate technology for medical waste disposal arises from the fact of increasing COVID patients in the country. The major constraints to be taken are the social distancing efforts to control the COVID spread, difficulty in segregating the waste, the huge quantity of waste being generated each day and the infrastructure and human resource scarcity in the COVID period. The technology for medical waste management should invariantly address these constraints.

2.1 Controlled pyrolysis for medical waste management

Newer technology plasma pyrolysis process fulfils all the technical requirements to treat hazardous waste safely. It is easy to maintain the arc in an oxygen-free environment, or one can vary the plasmagen gas to alter the chemistry of the process. The plasma pyrolysis system can have instant start and shut down. It is possible to add features like interlocks and automation that make the system user-friendly. The plasma pyrolysis technology overcomes almost all the drawbacks of the existing waste-disposal technologies. But Plasma is the state of matter obtained by breaking down atoms into ions and electrons by the process of ionization. Plasmas can quite easily reach temperatures of 10,000 degree Celsius. In plasma pyrolysis, generation of heat is independent of chemistry of material used. It is fast heating –

5000 Celsius can be achieved in milliseconds. Ironically this is the basic disadvantage of this technology. Creating and maintaining a chamber to withstand a temperature of above 10000 degree Celsius is practically not feasible, particularly when you need the waste management system in bulk and less time. [5]

Here the incineration employing controlled pyrolysis technique will be useful. The only factor to be considered is the selection of the controller for temperature of chamber.

The major factors influencing the pyrolysis include chemical composition of the feedstock, cracking temperature and heating rate, operation pressure, reactor type, residence time and application of catalyst. Temperature dominates the cracking reaction of the materials. Not all of the materials can be cracked by increasing the temperature. Van der Waals force is the force between the molecules, which attracts molecules together and prevents the collapse of molecules. When the vibration of molecules is great enough, the molecules will evaporate from the surface of the object. However, the carbon chain will be broken if energy induced by van der Waals force along the polymer chains is greater than the enthalpy of the C-C bond in the chain. This is the reason why high molecular weight polymer is decomposed rather than is boiled when it is heated. In theory, the temperature of thermal breaking the C-C bonds should be constant for a given type of plastic (polymer). Therefore if incineration is done through controlled pyrolysis, even the plastic waste associated with the no-segregated waste will also be processed.

The other operating thermal dynamic parameter is heating rate. The term "heating rate" in this field means the increase of temperature per unit time. Normally, in a fast or flash pyrolysis, heating rate refers to the temperature change of the plastic from it dropped on the hot surface till decomposed and vaporized. Once the feedstock is heated to the cracking temperature, the temperature remains relatively constant until all feedstock has been pyrolyzed. Another important factor is Operating pressure. The boiling points of the pyrolysis products are increased under higher pressure. Therefore, under pressurized environment heavy hydrocarbons are further pyrolyzed instead of vaporized at given operation temperature. In effect, under pressurized pyrolysis, more energy is required for further hydrocarbon cracking. It was also found that high pressure increases the yield of non-condensable gases and decreases the yield of liquid products.

2.2 Experimentation equipment

The prototype equipment used for experimentation and conversion machine is shown in Figure 1. The machine has two major parts: Conversion and Condensation chambers. Conversion chamber consists of a chamber in which plastic waste are fed. An outlet is connected from the conversion chamber to the condensation chamber. When plastic waste undergoes high temperature and pyrolysis, gases are formed

Figure 1 (Conversion and Condensation machine)

which is collected and passed into the condensation chamber. In the condensation chamber, the gas is condensated and a liquid is obtained as the output.

The response of the system and the quantity of the fuel generated is controlled by the manner in which the pyrolysis temperature is controlled inside the conversion chamber. An electronic controller is designed for serving this purpose which acts as the key element of this machine.

2.3 PID controller for the process

A PID controller is used as the basic temperature controller. (Figure 3)

The PID controller is the summation of P, I and D control whose equations are given in the Figure 2.

$$u_{PID}(t) = u_p(t) + u_i(t) + u_d(t) = k_p e(t) + k_i \int_0^t e(\tau)\,d\tau + k_d \frac{d\,e(t)}{dt}$$

Figure 2

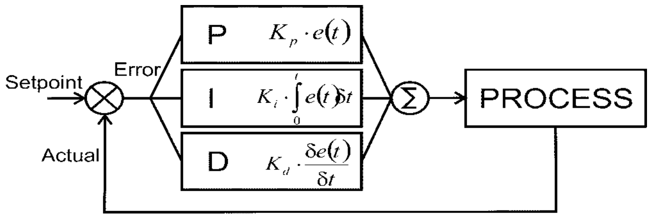

Figure 3.

2.4 Procedure for experimentation

Simulated hospital waste (cotton + plastic = 2: 1) is fed in the primary conversion chamber. A continuous water supply is maintained for cooling the rubber beading of the input door and the condensation chamber. The system settles much faster at 450 degree centigrade and the fuel starts flowing from 25 minutes.The entire medical waste is found to be transformed into fuel and non toxic fumes of less volume. The time taken for complete the process of processing medical waste of 250 gm is less than one hour.

Table -1: Sample Table format

Parameters	Experiment
Weight of input	250 gm
Set point temperature	450 degree Celsius
Volume of fuel obtained	75 ml
Time to reach set point	42 minutes

3. CONCLUSIONS

World agrees upon the upcoming demand for appropriate waste management in medical domain. Considering the fact that all health workers are involved in providing treatment for covid 19 patients and risk involved in handling the medical wastes, the immediate solution is nothing but the scaling up of capacity of existing medical waste management system. The technology of Plasma pyrolysis is appropriate when it is feasible to provide chambers to handle temperatures above 10000 degree Celsius. Alternate appropriate technology is to utilize the controlled pyrolysis for medical waste management. The byproduct of the process will generate a liquid which can be refined and used as a fuel.

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