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MECHANICAL DESIGN CONSIDERATIONS OF INDUCTION-HEATED PYROLYSIS REACTOR FOR WASTE TREATMENT AND ENERGY RECOVERY

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Abstract. *The global waste treatment policy has been developed with emphasis on incineration, aiming to reduce the amount of waste at final landfill disposal. Incineration has been the major waste treatment method until now. However, wastes cannot be treated as valueless garbage. Resource recovery and is one of the prime objectives in a sustainable waste management system. Conversion of medical waste (MW) to usable energy forms has gained much interest recently due to increase in energy cost as well as greater pressure on the environment by the use of fossil fuels. Thermal chemical conversion processes as pyrolysis and gasification are some of the favorable options that may be applied to effectively employ MW residue as source of energy production. In this experimental work, an induction-heated pyrolysis and gasification reactor is designed to evaluate the MW thermal chemical conversion process and stack gas emissions. This paper attempts to discuss the generalized design consideration for induction-heated pyrolysis and gasification reactors.*

Keywords: *Pyrolysis; Waste-to-energy; Stack emissions; Induction-heated reactor*

1. INTRODUCTION

Worldwide electrical energy demand is dramatically increasing every year, and will continue to do so for the near future. Along with the demand for more electricity comes a range of environmental problems caused by whatever energy bearing resource is being used to create the electricity. There is need for identifying the sustainable energy options for energy production without polluting the environment. The renewable energy sources can play a major role for sustainable development.

Many researchers have reported a wide variety of waste streams can be used for power production by the process of the pyrolytic gasification that in conjunction with recycling technology can dramatically reduce the need for landfills.

The pyrolytic gasification was developed in the 1970s, as an alternative to incineration. This is a technology for decomposing any waste containing carbon materials into gases and liquids by heating them in an atmosphere where there is little oxygen content.

Heat sources generally utilize combustion heat of fossil fuels, however heating of the pyrolysis tank by electric resistance heaters is also utilized.

2. DEVELOPMENT

Pyrolysis and gasification are thermal processes: they use high temperatures to break down any waste containing carbon. This technologies use less oxygen than traditional mass-burn incineration. The pyrolysis process degrades waste to produce char, oil and process gas (called pyrolysis gas). The gasification process then breaks down the hydrocarbons left into a pyrolysis gas and char using a controlled amount of oxygen to produce syngas made up mainly of carbon monoxide and hydrogen, with smaller amounts of carbon dioxide and methane.

Syngas has a calorific value, so it can be used as a fuel to generate electricity or steam, or used as a basic chemical in the petrochemical and refining industries.

Gasification and pyrolysis typically rely on carbon-based waste such as paper, petroleum based wastes like plastics, and organic materials such as food scraps and can be used as alternative to MW stream.

Most gasification and pyrolysis processes have four stages:

- Pre-treating the waste, which usually involves sterilizing it and separating out some of the recyclables, especially glass, grit and metal (which have no calorific value);
- Heating the remaining waste, mainly organic pulp, to produce gas, oils and char (ash);
- ‘Scrubbing’ (cleaning) the gas to remove some of the particulates, hydrocarbons and soluble matter;
- Using the scrubbed gas to generate electricity and, in some cases, heat (through combined heat and power – CHP).

Most alternatives to mass-burn incineration being developed now use a combination of pyrolysis and gasification.

2.1 Medical waste

Medical wastes are classified as hazardous wastes, which pose great risks to the staff, the public, and the environment, and have become an increasingly important issue for countries all over the world. The main treatments employed today are incineration and landfill. However, these are far from optimal treatment options, because they can raise environmental issues, like toxic and greenhouse gas emissions, leachates etc.

Considering the characteristics of medical wastes, pyrolytic gasification is a promising method which is an improvement of the traditional incineration in terms of air pollution. Using this technology, it is possible to control the combustion rate of the waste and product distribution and, therefore, reduce the air pollutants produced in the process.

The most remarkable characteristic of medical waste is heterogeneity. Medical wastes are classified into organic and inorganic matter. The former mainly contains paper, plastics, cotton sticks, textile fabrics, pathological wastes, and many other types of organic materials. The latter mainly comprises grasses, metals, moisture, and other types of inorganic materials. Obviously, plastics and fibers are the most representative and combustible constituents of medical waste. Consequently, some attention has been given to evaluate pyrolysis and gasification of these materials in various types of gasification systems.

2.2 Types of pyrolytics gasification reactors

Various types of pyrolysis reactors were designed for production of bio-oil from different agricultural wastes. Some of these reactors are,

1. Fixed-bed/Moving-bed reactor
   1.1. Updraft
   1.2. Downdraft
   1.3. Crossdraft
2. Fluidized bed reactor
   2.1. Bubbling fluidized-bed
   2.2. Circulating fluidized-bed
3. Entrained flow reactor
   3.1. Top-fed
   3.2. Side-fed
4. Plasma reactors

Out of these reactors updraft reactors is one of the oldest and simplest of all designs easy to construct, cheap and requires less maintenance.

2.3 Basic consideration for selecting pyrolytic gasification reactor

The design of a pyrolytic gasifier involves both process and hardware. The process design gives the type and yield of the product, operating conditions, and the basic size of the reactor. For any design, specification of the plant is very important. The imput includes,

1. Type of reactor
2. Material of construction that can be with-stand at high temperature.
3. Diameter of reactor
4. Height of reactor
5. Feed material used with their particle size

6. Rate of heating in ˚C/min
7. Insulation material
8. Temperature sensing element

2.4 Design and construction of pyrolytic gasification reactor

Fig. 1 presents schematically the experimental setup which will be constructed to study the pyrolytic gasification of the MW. The main components of this setup include a gas feeding system, a gas preheater (5 kW) for heating the feed gas to a certain temperature, a fixed-bed reactor, a bed heater (10 kW) for heating the reactor to the desired temperature, a condenser, a scrubbing bottle to cool and clean the gaseous stream, and thermocouples linked with display units. The bed heater is installed around the reactor wall. A thick layer of heat insulation cotton covers the outside of the heater.

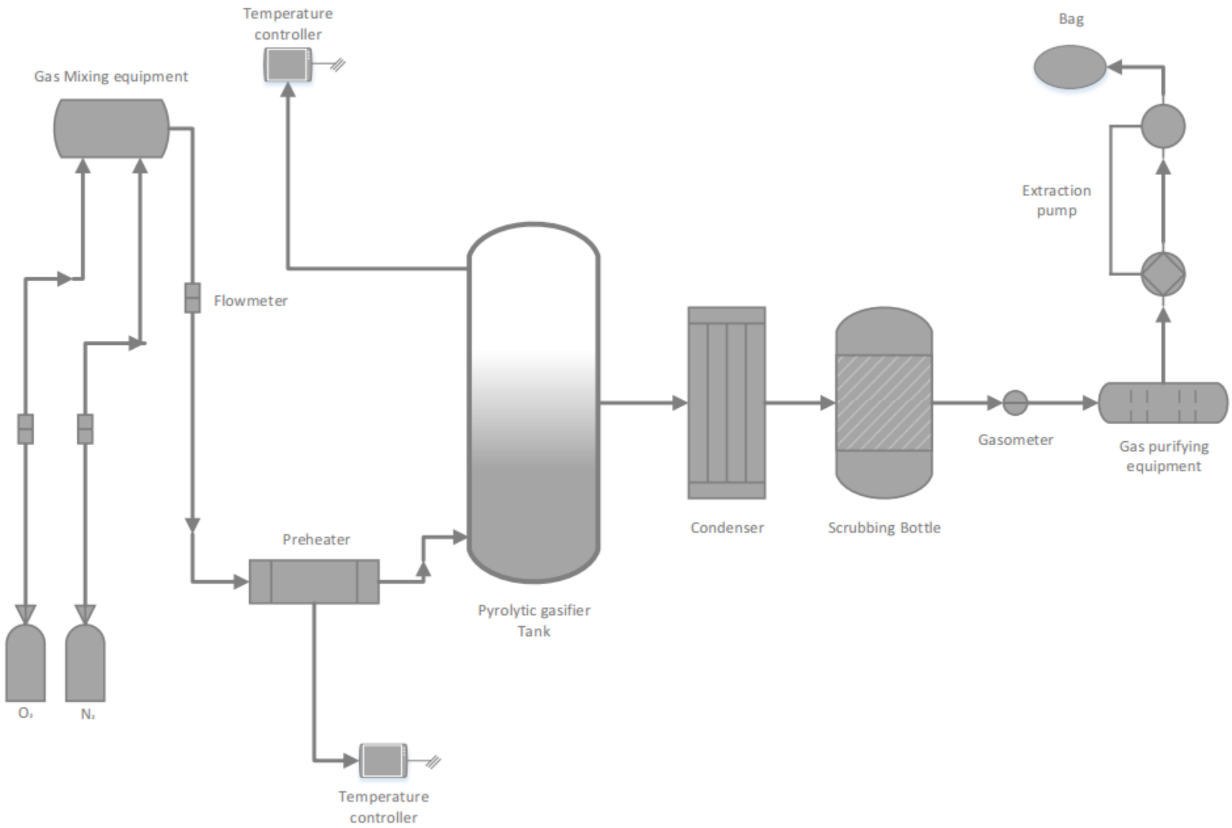

Figure 1. Schematic diagram of the experimental setup.

The reactor is a cylindrical, batch type, fixed bed reactor. The top side of reactor can be open for feeding the raw material and solid residue (char and ashes) can be removed at the end of the experiment. The temperature inside the reactor is measured by using K-type thermocouple. During the reaction, the top side is kept closed by a cover plate tightly secured to the flanged opening. The reactor weighs approximately 18-23 kg. The temperature inside the reactor is measured by a thermocouple.

An instrumentation panel, that consists of a fuse unit, MCB, on-off switch and, temperature controller. The temperature of the Pyrolyser is measured by a K- type thermocouple connected to a digital temperature indicator of 1°C accuracy. The time is measured by a digital timer of 0.01 second accuracy. The weight of input feedstock and residue after process are measured in each test.

2.5 Experiments

The experiments will be conducted by maintaining the pyrolytic gasifier reactor under various conditions. Gasification process will be carried out by changing the parameters like temperature, heating rate, feedstock particle size, amount of feed material, oxidation air, etc. Different temperature conditions and heating rate are required for different feed and types of process.

3. CONCLUSION

Pyrolysis and gasification of MW is more flexible than incineration because of their modular way of operating. They may have some advantages in terms of human health, although firm conclusions are impossible to draw because toxicity is notoriously difficult to measure. However, three conclusions are clear:

The reactor is easy to install and requires less maintenance. The reactor can reach greater stability at high temperature. The reactor system does not require any complicated components and easy to study at various conditions.

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