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Valorization of Solid Waste Using Fluidisation

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Abstract:
The Pyrox process is a process of gasifying solid waste which implements the phenomenon of fluidisation. The process is used to produce fuel gas from the waste which can be then combusted to produce energy. This fuel gas can thus be a greener and more economical alternative to other conventional fuel sources.
Key Word: Fluidisation, Gasification, Pyrox process, Energy, Conventional fuel.

I. Introduction

Fluidisation is a process in which solid particles are made to act like fluid when a stream of gas or liquid is passed through it. Based on the flow rate of the fluid, there are various regimes of fluidisation. As the flow rate of fluid through a fixed bed of solids is gradually increased, a specific point is reached where the drag forced imparted by the flowing fluid equals the weight of the particle. This causes the bed to expand and the particles are suspended. This is the beginning of fluidisation and is referred to as incipient fluidisation. On further increase of flow rate, formation of bubbles occur which causes bubbling fluidised bed. With increasing flow rate, the bubbles coalesce and grow. If the diameter of the vessel is small enough, the growing bubbles spreads across the vessel creating large voids in the bed. This is called as slugging. At a very high flow rate, the velocity will exceed the terminal velocity of the particles and the upper part of the bed disappears and a turbulent motion of solid particles and bubbles can be observed. This is referred to as turbulent bed. On further increasing the flow rate, the fluidised bed becomes an entrained bed and pneumatic transport of solids occur. Due to the large volumetric concentration of interface surface, fluidised beds have high heat and mass transfer capabilities, and thus fluidisation has a wide application in numerous physical and chemical operations.

II. Gasification of solid waste

Gasification is a process in which carbonaceous materials are thermally converted into combustible gases. The gasification process can be used to gasifiy wastes produced from various industries to produce dry gas which can be used as a fuel to generate power by its combustion. [3] Japan developed an efficient process of gasification to treat waste by extending the concept of Kunii- Kunugi process, known as the Pyrox process. The process consisted of two fluidised- bed vessels, namely gasifier (cracking reactor) and the regenerator. These were connected by two downcomer lines through which sand was circulated by the action of gravity. The process also consisted of two evaporators that provided steam to each of the vessels which was used to provide heat as well as to fluidise the sand. Sand is used as a circulating medium due to its ability to retain heat for a longer period of time because of its low specific heat capacity (830J/kg.K) and low thermal conductivity (0.25W/m·K).

The dry waste was shredded to desired size range and was fed to the cracking reactor through a hopper. The carbonaceous materials in the feed were then gasified by heat provided by the sand and the produced combustible gas was discharged from the top of the reactor. The char which was left was circulated by the means of sand to the regenerator where it was burned completely. The heat released by the combustion of this char heated the sand, which returned to the gasifier to provide energy for further gasification. Thus, the temperature in the regenerator was higher than that in the cracker by 50^{o}C. Ash and tar were removed from the bottom of the reactors.

A pilot plant was set up applying this process with a capacity of 10kg/h solid waste taken from an incineration plant. The waste was shredded to a size range of 1mm to 6mm and the temperature of the reactor was maintained at 700^{o}C. The net calorific value of the dry gas obtained was around 12.2MJ/kg to 14.7MJ/kg (3500kcal/Nm^3 to 4300kcal/Nm^3) depending on the composition of the gas. If CO_2 was removed from this dry gas, a clean fuel gas with a net calorific value as high as 31.5MJ/kg to 38.1MJ/kg (5700kcal/Nm^3 to 6900kcal/Nm^3) could be obtained.

A case study for the application of sustainable, gasified waste, converted to fuel is illustrated as follows
Basis: Energy load of 1600MJ/tonne of product

Mass of fuel gas from waste required to supply 1600MJ/tonne of product $= \frac{1600}{31.5}\ to\ \frac{1600}{38.1}\ kg\ of\ gas$ (see Table.1)

$= 50.8\ to\ 42$ kg of gas

Mass of natural gas required to supply 1600MJ/tonne of product $= \frac{1600}{47.1}\ of\ natural\ gas$

$= 33.97$ kg of natural gas

Table.1 [4] Comparative table for calorific value of fuels

Fuel	Calorific Value (MJ/kg)	Amount required (kg)
Gas produced from gasification	31.5 – 38.1	50.8 – 42
Methane	50	32
Natural gas	47.1	33.97
Petrol	43.4	36.8
Coal (bituminous)	29	55.17

III. Result and Discussion

It is seen that the mass of fuel gas required for meeting the energy load is less than the mass of coal for the same duty. However, the mass of fuel gas required is slightly higher than that for natural gas, methane and petrol. Thus, it is a cleaner, sustainable and cheaper alternative to other fuel sources.

IV. Conclusion

The solid wastes can be gasified effectively using fluidisation to produce a fuel gas that could be utilised to generate the same amount of energy as other fuel sources. Therefore, it can be concluded to be an affordable and viable fuel source.

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