BIOGAS TECHNOLOGY BASED ON VALUING THE URBAN AND AGRI-FORESTRY SOLID CUMBERSOME WASTE

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Abstract. *The study proposes a new process and plant construction for the gasification (through pyrolysis) of solid urban forestry and agricultural cumbersome waste that provides the obtaining ecologically three products: 1. synthesis gas with a high calorific power, resulting from the pyrolisis of the organic materials (wood, paper, forestry, agriculture and food industry waste, etc.). This gas can be used in producing second generation biofuels, including hydrogen 2. an alloy of liquid metal, used in the metallurgical industry; 3. a molten slag (usable after the hardening in the foundry or in building, mainly in road lying). The proposed biomass (waste) gasification process and of resulting gas using have several steps: collection; processing; gasification; gas cleaning and gas use (compressed 80 % for the use as fuel and 20 % can be liquefied). The syngas process has a high energy efficiency by a high purity of the synthesis gas and of a relatively low temperature (300-500 °C) in the purpose of direct use of the gas for producing heating, electricity and/or second generation biofuels. The syngas plant provides the continuous synthesis gas supplying during its whole working time (reaching decades) and can be used in the municipal landfill reducing in time their dimensions and in the rural areas (forestry or agriculture), also, for the gasification the solid waste specific for these areas (straw, grass, seeds, leaves, branches, etc.), case in which the plant of suitable dimensions can be mounted on a trailers to be moved at the biomass waste deposits. The main product (syngas) may be transformed in ethanol, other fuels or chemicals (even hydrogen), or in electricity and heat by very known procedures.*

Keywords: recovery, cumbersome, biofuels

INTRODUCTION

The **UE Landfill Directive (99/31/EC)** sets targets to reduce landfilling of biodegradable municipal waste to 75% of 1995 levels by 2006, 50% by 2009 and 35% by 2016. In order to achieve these targets each EU member state must develop national strategies to implement the DMB landfill reduction. Generally, following the missing of proper arrangements and of critical use, the landfills are between the recognized generators of risk and stress for environment and public health. The 1999/31/EC Directive of EU Council has establish several norms regarding the landfill that must be strictly followed, unaffected by the material or financial possibilities of the administrators of these areas

Romania as a member of the EU have to respect the European Norms regarding the exhaust emissions reduction by using the biofuels. According to the Romanian Government Decision regarding the promotion of the use of biofuels and other renewable fuels for transport, the quantity that must be achieved is min. 2 %, calculated to the energy content of all types of petrol and diesel oil existing on the market at the country admission in the EU and minimum 5,75 % calculated on the basis of all types of fuel used in transport, introduced on the market till 31.12.2010.

Recently a new technology was developed for producing syngas by pyrolisys of industrial and municipal wastes using plasma. This technology is a real progress because wastes, are used in their initial form, without any preparation (which is expensive and requires a lot of handling). Unfortunately, this new technology needs expensive electric installations (which produce direct current) and plasmatrons. It also has the disadvantage of supplying a diluted syngas, which has in consequence reduced caloric power. An other disadvantage is the water flowing into equipment in case of (frequent) damages of water-cooled plasmatrons. In the proposed technology we replaced plasmatrones with an electrical resistance material (slag), heated to the temperatures between 1800-2000 ^{0}C, (more that necessary temperatures for pyrolisys (700-1200 ^{0}C). Therefore, our equipment is simpler, cheaper and more reliable.

Biogas produced from the municipal cumbersome can provide a clean, easily controlled source of renewable energy from organic waste materials for a small labour input, replacing firewoood or fossil fuels (which are becoming more expensive as supply falls behind demand). During the conversion process pathogen levels are reduced and plant nutrients made more readily available, so better crops can be grown while existing resources are conserved.

MATERIAL AND METHOD

The urban waste usually contain: litter, street waste, industry waste, building waste, etc. The principal characteristic of this waste is its heterogeneity, with high variations from a municipality to another and according to the season, geographical position, municipality size, collection fervency, life style and level of life quality, population degree of education, heating system, packing system, etc. For example in 2009 the composition of urban waste in the case of the municipality Cluj-Napoca included: 1,5…2,2 % metals, 1,3…2,1 % glass, 2,5…3,4 % textiles, 4…5,7 % plastics, 8…10 % paper, 60…65 % organic materials and 15…22 % other materials. The waste humidity is situated in very large limits, between 25…60 % at a specific weight 300…400 kg/m^3 and a calorific power of 600…900 kcal/kg. According to the above description the waste materials represent an important source of pollution and in the same time, an interesting alternative energy source. Starting from this point there were investigated the optimum modalities for solving this important problem of waste materials and of the use of their available energy.

In these conditions the gasification of the cumbersome waste is actually an important alternative to conventional fuels. In the last years, according to the increasing the price of the fossil fuels and environment stress, the gasification become a modern and high-level technology. In essence the gasification is a thermo-chemical process of biomass transformation in the so called generator gas that contains oxi-carbon, hydrogen, methane and some inert gases (mainly nitrogen). The generator gas can be used in the internal combustion engines, with some changes. The advantage of this technology consists in the decentralized systems for energy conversion that can work economically even in small size. Actually, because the continuous fossil fuel price rising and of environment stressing the gasification become a modern and sophisticate technology. The gasification technologies have a great diversity. Theoretically any biomass with a humidity content of 5…10 % can be gasified, but practically not any biomass can provide a right quality generator gas. The key of obtaining a high quality gas is in the understanding the properties and thermic behavior of the used fuel for its supplying.

The first generation of biofuels could be obtained by the anaerobic fermentation (biogas, bioethanol, etc.) or the aerobic one of the urban, forestry, agricultural, industrial, etc. waste. There can be used other technologies, but these are actually too expensive or not accessible for the Romanian entrepreneurs.

The second biofuels generation can be obtained by the synthesis gas that results, for instance, by gasification or pyrolysis of these waste in gas generator using mainly pure technical oxygen and industrial steam, produced in complex and expensive plants. More, these plants require complicate devices for the preliminary preparation of the raw materials and for the synthesis gas cleaning. In the same time the calorific power of the resulting gas is relatively reduced because of using the oxygen and technical steam.

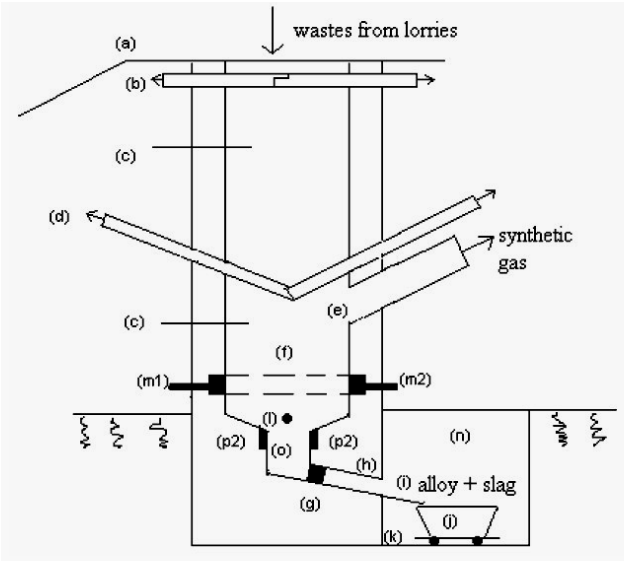

Fig. 1. The syngas principle scheme

In the last period it was proposed a new technology for the gasification of solid municipality waste by pyrolysis by the help of plasma and with out being necessary the expensive and laborious preparatory phase. This technology represents obviously an important technical step forward, but has several impediments, such as: the use of expensive electrical plants for producing the continuous electricity, of complicated and scare plasmatrons and the dilution of the synthesis gas by the plasma carrying gas resulting, in the same time, the diminishing of its calorific power. In figure 1 it was presented the syngas principle of the syngas plant that is compound of: (a) superior plane of the scaffold - were trucks are coming for unload wastes directly in our installation; (b) is the upper lid of the vat, whose two halves can be translated horizontally, allowing wastes to fall down; (c) is the vat which has an inferior lid; (d) sloping and being hermetically closed in order to avoid the evacuation of any syngas produced below in the equipment.

The place designed for the syngas to be evacuated is (e) the hole of the pipe, which is sloped in such a manner that any solid particle which reaches this point will return in the vat aided by the gravitational force. The resulting gas is evacuated continuously 24 hours a day, 365 days an year, during more than ten years, towards the purifying installations and further to the end users (electricity or fuels and chemicals makers). This is an essential difference here comparing with the process using plasma ovens, which must to interrupt syngas supply, during each loading of wastes. After introducing the content of 6-8 waste collecting trucks in the space between the inferior and superior lid, the (b) lid is closed hermetically and next the (d) lid opens, so that all wastes are going down at the inferior part of the vat (c). In this place occurs the pyrolisys of wastes (decomposition in absence of the air, which gives to syngas maximum caloric power), having contact with molted slag layer (at a temperature of 1800 -2000 ^{0}C, which is maintained electrically, or by contact with electrodes similar with those used in arc electric furnaces, or by electromagnetic induction). Having contact directly with solid waste, in their way out, these gases give up important quantity of their heat, so that at the exit of the vat they remain at only 300…400 ^{0}C. Metallic and inorganic parts of the wastes, which would not decompose in molecules and atoms (i.e. syngas) when they reach the layer of overheated slag will melt into an heavier mass of metallic alloy and will descend to the bottom of the vat (c); some slag will result for inorganic materials and will be added to the existing mass of slag.

An electric sensor will signalize audio and visual the moment when the alloys level is at maximum in the vat (c), announcing the moment for the evacuation of the alloy and of some part of the melted slag. The evacuation is made by destroying the plug (g) in the beginning of the evacuation pipe (h). All the metallic alloy and some of the slag are evacuated through the orifice (h) and the drain (i), finally falling in the founder ladle (j) on the truck (k). The signal for the obstruction of the pipe with a new plug is given by the rising of the elec-tric resistance between the electrodes (m), those which ensure the overheating of the slag (f).

The method and technique of melting and remaking the plug are well-known by metallurgists and are not described here. In the next moment, the ladle (j) is lifted from the evacuation pit (n) and transported towards the casting moulds for metal and for slag, or towards the installation of breaking in small pieces of the slag (to the granulator). In the meantime, of functioning, there is taking care of the cleaning of the remains on the evacuation hole (h) and on the drain (i).

The process is continuous, making an important difference compared with the plasma procedure, where the supply of syngas is discontinued every time a new truck is introducing wastes. In the center of the vat bottom (c) we designed a cavity (o) in order to better collect the melted alloy. At the top of this cavity, we have set two graphite electrodes (p1 and p2) for eventually connecting with the N phase of the electric transformer (whose active phases R, S, T are powering the electrodes (m) for maintaining the slag in overheated state.

The process is starting by forming the mass of slag (f). For that we are covering the bottom of the vat with small pieces of glass till the level of the contact electrodes (m), than between these two electrodes we form some conductive rows of metallurgical coke of the same high as the electrodes, and the species between these rows we are covering with a mixture of glass, sand, lime and bauxites, in such proportions as to supply a conductive melted slag, fluid, at a working temperature of 1800 – 2000 ^{0}C. Over this layer we place another glass layer and on the top, under the level of inferior lid (d), will be a layer of wastes. We hermetically close the inferior lid (d), starting the electric heating. Shortly after, the stop of the installation exits the expected syngas. The emissions of gas before this moment are evacuated by an metallic chimney. The urban, forestry and agricultural solid cumbersome waste entering in contact with this melting slag, having temperatures of 1800-2000 ^{0}C, dissociate in molecules and atoms, resulting from all the organic substances. In the same time the metallic and an-organic substances from the waste are melting forming a metallic alloy and a slag that are evacuated periodically from the plant and cast in cakes or in paving bricks or are grained.

The gases resulting from the contact of the organic materials in contact with the melting slag have a high temperature (till 2000 ^{0}C), fact that allows their participation to the decomposition in molecules and atoms of a part of the organic waste positioned in their way to the special exit orifice. In these decomposes processes, as in the case of simple preheating the gases gave up a great part of their heat (enthalpy) and leave the plant at 300…500 ^{0}C (much lower than in the plasma plants), fact that allow their dedusting in simple and cheap plants (from the type of cyclones or scrubbers) being used afterwards directly to the obtaining second generation of biofuels, including hydrogen. The plant sealing in the solid waste input area is made by the help of two mobile caps that closed perfectly and are situated at different levels on vertically so that in the plant space between the two caps can enter the content of about two-three collecting autos.

Another method of melting the slag (f) is the aluminothermal one. It is a rapid, but expensive method, also. The third possible method of getting the slag melting is the one in which we add at top of the glass layer the slag (exited previously from our installation) melted in a small exterior special oven. If necessary the installation can be stopped when the wastes are no longer introduced in the equipment, the melted metallic alloy and the slag are evacuated and so there is room for repairing the refractory lining and /or the faulty mechanisms (if there is no possibility of doing this while the installation is running). Otherwise, the system can function continuously for decades without interruption (lake blast furnaces do).

The syngas plant can be constructed near the municipal dump heaps, or near the enterprises that are producing much wastes. Another interesting option is the installation mounted on a mobile structure in order to be transported to the raw materials storage place (e.g. in rural areas). So are cut off the raw materials transport costs, but are increased the machinery costs.

CONCLUSIONS

In essence the proposed syngas process consists in solid cumbersome waste transforming in synthesis gas and excluding the unconvenient of the gas generators used actually, including the ones belonging to the gasification by the plasma use. The proposed biomass (waste) gasification process and of resulting gas using have several steps: collection; processing; gasification; gas cleaning; gas use – compressed 80 % for the use as fuel and 20 % can be liquefied.

The urban, forestry and agricultural solid cumbersome waste entering in contact with this melting slag, having temperatures of 1800-2000 ^{0}C, dissociate in molecules and atoms, resulting from all the organic substances. In the same time the metallic and an-organic substances from the waste are melting forming a metallic alloy and a slag that are evacuated periodically from the plant and cast in cakes or in paving bricks or are grained.

The proposed process provides the gravimetric descending of the solid cumbersome waste in a shaft lined with cheap ceramic materials (comparatively with the ones required by the plasma use) and their contact with a malting slag layer maintained in this form by well known metallurgical ways, proofed as efficient by the long term use in this industry, or by the electric flame in alternative or direct current. The main product (syngas) may be transformed in ethanol, other fuels or chemicals (even hydrogen), or in electricity and heat by much known procedures. The creation of a biofuels industry will create new employment and consequent tax revenues. These should go some way to balancing the cost of the relevant fuel duty rebates.

The use of biogas is increasing rapidly today for a number of reasons, such as: fuel costs have been rising steadily for a number of years and the taxation burden increases as well, leading to a double load of the user to bear; attempts are now being made to improve the use of renewable energy sources; the gas produced, mainly methane, is one of the major causes of the greenhouse effect; the production is possible in small scale sites, obviating the need to supply energy to outlying areas; even a very basic construction using mostly used materials will produce gas if a few simple design rules are followed.

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