УДК 628.4.04-405
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PROJECT DEVELOPMENT ON MUNICIPAL WASTES STREAM MINIMIZATION WITH SIMULTANEOUS ALTERNATIVE SOURCE OF ENERGY OBTAINING

Проаналізовано існуючі технології збору звалищного газу і переробки неорганічних відходів та запропоновано схему збору звалищного газу з системою енергопостачання міні-заводу по утилізації ПЕТ-пляшок та альтернативне пластикове покриття для полігону у місті Київ.

Проанализировано существующие технологии сбора свалочного газа и переработки отходов, предложено схему сбора свалочного газа с системой энергоснабжения мини-завода по утилизации ПЭТ-бутылок и альтернативное пластиковое покрытие для полигона в городе Киев.

Present technologies of gas collection and waste processing were analyzed, the scheme of gas collection was offered with the system of energy supply of PET-bottles recycling mini-plant and alternative plastic cover for Kiev landfill.

Producing of electrical energy with the purpose of transporting and selling it into network is the most popular way of landfill gas utilization. That tendency of collecting and utilization of landfill gas from landfills are popular in many countries, but volume of its extraction is very low comparing of its formation. It gives wide range of opportunities for developing of landfill gas as alternative source of “blue” fuel.

The main components of landfill gas are methane and carbon dioxide. Both components contribute significantly to the greenhouse effect and are chiefly responsible for global temperature rise. Thus it is vital to avoid unused emissions to the atmosphere. So, by the use of landfill gas we substitute fossil fuels and reduce emissions of carbon dioxide and methane considerably. Greenhouse gas emission levels in Ukraine are notably lower than those for the year of 1990 (base year under the Kyoto Protocol), and this fact gives an excellent opportunity for Ukraine to benefit from projects of joint implementation.

Landfill gas odors are produced by bacterial or chemical processes and can be emitted from both active and closed landfills. These odors can migrate to surrounding community. Benefits of project are in reduction of odour problems and safe sanitary conditions at the landfill by gas collecting system implementation.

Landfill gas utilization is proposed to applicate at landfill №5 in Kiev, with total area 56,3 hectare which situated in Obukhiv region near Kiev among villages Krenichi, Pidgirzi and Dmutrovichy which place solid domestic wastes and industrial wastes of III and IV classes of hazard.

Experimental installation of PET-bottle recycling plant with system of landfill gas collecting was based on Lugansk experience. During 2002-2003 at Lugansk landfill was realized demonstrational project in the framework of Ukrainian-American program EcoLinks “Decreasing of greenhouse gases emission into atmosphere by the way of methane collecting and utilization at landfill of Lugansk”. Company SCS Engineering (USA) took part in such project as foreign partner. It was planned to develop project of landfill gas collecting and utilization with thirty drills and to drill three demonstrational for gas burning in flare.

Landfill № 5 already placed 9,1 mil. m^3 and landfill in Lugansk collected more than 10 mil.

m^3, and it is not operating in our days. They have the same area, because engineered capacity of Kiev landfill is also 10 mil. m^3.

Today Lugansk landfill burning gas in flare, but they working on installation of system energy receiving form landfill gas. The most efficient is system of gas transportation through pipes to consumers for the purpose of natural gas replacement. Period of capital investments recoupment is one or one year and a half depending on native or foreign installation.

Producing of electrical energy with the purpose of transporting and selling into network is the most popular way of landfill gas utilization. This way is proposed to applicate at landfill №5 in Kiev. Amount of collected landfill gas allows installing gas electrical station with capacity 1500 kWt.

Decreasing of greenhouse gases emission in CO_2 equivalent tones, by means of methane emission into atmosphere and replacing of natural gas for producing of heat and electrical energy will be equal to 62 thousand t/year in case of landfill gas collecting and utilization project realization.

Landfill Gas Collection System installed during active life of landfill and completed at closure of landfill. There are such stages of system building:

- vertical wells drilled to bottom of waste;
- typically one well per acre;
- horizontal collectors in active fill areas;
- header pipe connecting wells;
- compressor places vacuum on wells;
- landfill gas delivered to gas electrical station.

Vertical wells should be drilled to the bottom layer of wastes at the whole territory of landfill. System of pipes connected wells and transferring collected gas to scrubber, where gas is purifying. After scrubber LG going to compressor and to engine generator, this can be replaced by gas electrical power station. For the Landfill №5 capacity of electrical station should be around 1500 kWt. Part of produced energy is going through power cable to PET-bottle recycling mini-plant. Other produced energy transferring to electrical network which supply final consumers (figure 1).

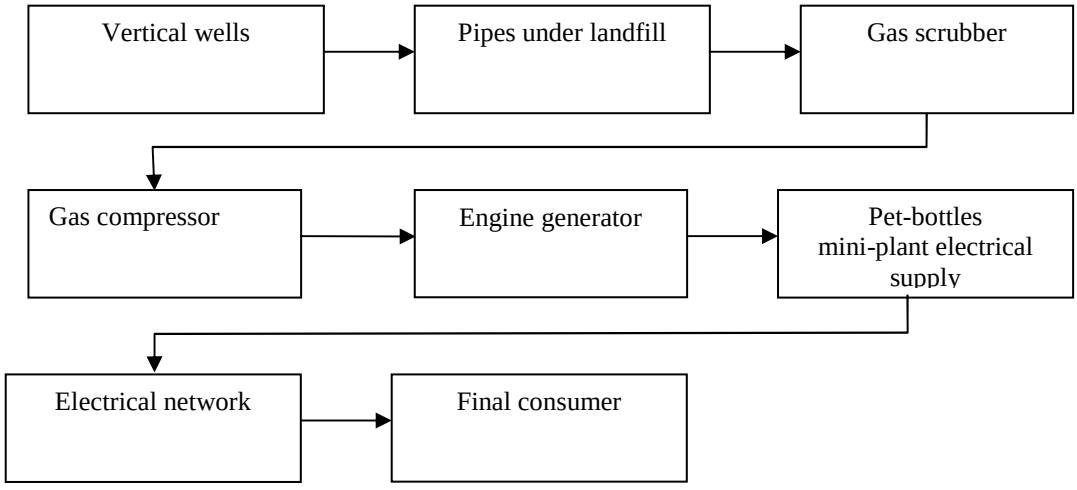

Figure 1 - Scheme of complex on landfill gas utilization

PET-bottle recycling plant capacity: approximately 300 kg/h. An average company operating the medium size disposal field for home wastes may collect up to 100 tons of used PET bottles per month. This amount is sufficient for the full-time running of mini-plant, but definitely is not enough for the medium and higher capacity industrial scale equipment. Consequently the collected bottles either should be recycled at sight or moved from the disposal field to the production facility which is often remote by substantial distance. This brings to essential rising of

overheads associated with baling, increasing transport costs, intermediate warehousing and additional handling, loading and unloading works. Furthermore, it is an important aspect of “disposal field bottles” transportation involved, extremely heavy contaminated, often badly sorted material and hence up to 30% of the mass is just loss at converting it into flakes.

It was analyzed that professional PET bottle recycling plant is very attractive for the small and medium companies which like to develop their business from scratch but are not prepared to invest high amounts at start up. This mini-plant is specially designed to be used by wide range of PET bottle recyclers worldwide: landfills owners, municipal or private waste collecting and sorting stations, plastics processing workshops, bottlers etc.

The entire plant is assembled inside 20 freight container. All machinery, piping and wiring are ready done. It should be connected to the water supply hose, sewerage hose and power supply cable to their sockets on the side of the container.

The market price of PET flakes depends on their overall quality, as defined by purity, color and size. This is result of many factors, such as collecting system, pre-handling, sorting and finally processing in the recycling plant. Depending on local conditions, costs for labor wages, electricity and fresh water tariffs, waste disposal, used bottles and the market for the final product, will need some time until founding the best choice to maximize profit.

PET flakes obtained in mini-plant are clean enough to be recycled into pellets for further processing by extrusion, injection molding or fiber manufacturing into a wide range of final products.

For the installation of landfill gas collecting system at landfill №5 first of all should be covered. As example of landfill cover is engineered according to requirement of Environmental Protection Agency (EPA). Problems included elevated chemical concentrations in on-site ground water to severe contamination of ground water at water supply well fields, surface water contamination, ecological impacts to local flora and fauna, and forced changes in the water supply for impacted communities where state drinking water contamination standards were exceeded. Current cover design criteria emphasize barrier layers that block infiltration of water through the cover into the waste. Saturated hydraulic conductivity is the measurement device chosen by the EPA to define the effectiveness of the barrier layer. The saturated hydraulic conductivity method can actually be detrimental to covers in arid and semi-arid regions. In order to achieve the low saturated hydraulic conductivity required by the EPA, the barrier soil must be remolded by compacting it 'wet of optimum' which eventually leads to the soil drying, shrinking, and cracking leaving the barrier layer ineffective. These cracks provide pathways for the infiltration of water. This defeats the original purpose of creating a barrier layer to block the infiltration of water into the waste.

Landfill covers costs should be less expensive than current systems because this effort should result in more efficient landfill cover designs tailored to specific site requirements by decision support system. The use of native soils will greatly reduce costs normally associated with clays and membranes which are required by the EPA.

Landfill №5 is open for now and extremely dangerous for environment. To install landfill gas collecting system it should be covered.

We propose to make plastic cover for landfill; it will be like hothouse and conserve the landfill. Developing of plastic cover should include pores for wells and produced out of recycled PET-bottles flakes. Production process of plastic cover includes standard process of plastic manufacturing, but will be made out of recycled flakes. Many plastics are blended with additives as they are processed into finished products. The additives are incorporated into plastics to alter and improve their basic mechanical, physical, or chemical properties.

There are several different processing methods used to make plastic products. Below are the four main methods in which plastics are processed to form the products that consumers use, such as plastic film, bottles, bags and other containers.

Extrusion - plastic pellets or granules are first loaded into a hopper, then fed into an

extruder, which is a long heated chamber, through which it is moved by the action of a continuously revolving screw. The plastic is melted by a combination of heat from the mechanical work done and by the hot sidewall metal. At the end of the extruder, the molten plastic is forced out through a small opening or dies to shape the finished product. As the plastic product extrudes from the die, it is cooled by air or water. Plastic films and bags are made by extrusion processing.

In injection molding, plastic pellets or granules are fed from a hopper into a heating chamber. An extrusion screw pushes the plastic through the heating chamber, where the material is softened into a fluid state. Again, mechanical work and hot sidewalls melt the plastic. At the end of this chamber, the resin is forced at high pressure into a cooled, closed mold. Once the plastic cools to a solid state, the mold opens and the finished part is ejected. This process is used to make products such as butter tubs, yogurt containers, closures and fittings.

Blow molding is a process used in conjunction with extrusion or injection molding. In one form, extrusion blow molding, the die forms a continuous semi-molten tube of thermoplastic material. A chilled mold is clamped around the tube and compressed air is then blown into the tube to the interior of the mold and to solidify the stretched tube. Overall, the goal is to produce a uniform melt, form it into a tube with the desired cross section and blow it into the exact shape of the product. This process is used to manufacture hollow plastic products and its principal advantage is its ability to produce hollow shapes without having to join two or more separately injection molded parts. This method is used to make items such as commercial drums and milk bottles. Another blow molding technique is to injection mold an intermediate shape called a preform and then to heat the preform and blow the heat-softened plastic into the final shape in a chilled mold. This is the process to make carbonated soft drink bottles.

Rotational molding consists of a closed mold mounted on a machine capable of rotation on two axes simultaneously. Plastic granules are placed in the mold, which is then heated in an oven to melt the plastic Rotation around both axes distributes the molten plastic into a uniform coating on the inside of the mold until the part is set by cooling. This process is used to make hollow products, for example large toys or kayaks.

All types of plastic products are classified within the plastic industry as being either a durable or non-durable plastic good. These classifications are used to refer to a product's expected life. Products with a useful life of three years or more are referred to as durables. They include appliances, furniture, consumer electronics, automobiles, and building and construction materials. Products with a useful life of less than three years are generally referred to as non-durables. Common applications include packaging, trash bags, cups, eating utensils, sporting and recreational equipment, toys, medical devices and disposable diapers.

To manufacture plastic cover we will use rotational molding and extrusion method of plastic producing. Plastic should be durable, expected life of plastic not less than 20 years. Cover is done in 3D-model by program Google SketchUp, the result is at the figure 2.

Economic efficiency of PET-bottles recycling plant was calculated according to program-calculator of business plans in Project managing sphere which called “Alt-invest Prime”.

Composition of landfill gas is very dangerous and has great potential as source of energy. It is economically and ecologically efficient to applicate landfill gas. According to data about potential of landfill gas one cubic meter of landfill gas has energy equivalent from 4 to 5 kWt·hour which is 0.5 liter of fuel. Only imagine potential of landfill when 1 ton of solid domestic wastes give 180-250 m^3 gas for the period 15-20 year. For example: amount of collected wastes 3,000,000 tons during 20 years. Amount of collected gas is around 2300 m^3/hour, but utilized amount of gas 1500 m^3/hour. Energy potential: 1500 m^3/hour = 7500 kWt·hour = 700 kg of fuel per hour, so more than 5000 tons of fuel per year during 15 years.

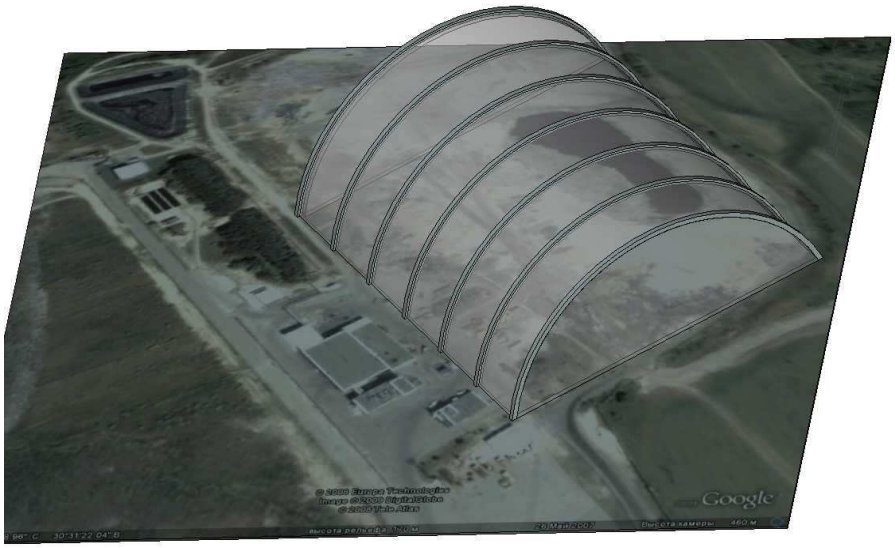

Figure 2 - 3D-model of the landfill cover

Capital investments are 300,000 USA dollars, planning horizon – 10 years, annual net profit from 78,633 USD for the first year to 183,741 USD for the last year. Profitability of investments is 183 %.

Conclusions.

- The use of landfill gas replaces fossil fuels and reduces emissions of carbon dioxide and methane.
- Plastic is non-degradable, it takes long time to break down, possibly up to hundreds of years - although no-one knows for certain as plastics haven't existed for long enough. By recycling of plastic wastes in mini-plant we decrease the volume of wastes at landfill (about 10-20% of total amount).
- Plastic recycling technologies consume a huge amount of energy, heating and electricity. It creates additional load on the environment. That is why mini-plant installed directly at landfill territory will solve these problems by energy supplying converting energy of landfill gas into electricity. It saves both environmental, fuel and energy resources.
- Plasdtic cover installation will improve organoleptic properties, reduce impact on the environment (it is made of recycled PET-bottles) and create more environmental friendly surroundings.

BIBLIOGRAPHIC DATA

1. *L.M. Johannessen.* Recuperation of Landfill Gas from Municipal Solid Waste Landfills/ L.M. Johannessen. – Amsterdam, – 1999. – 265 p.
2. *Israel Yu.* Ecology and environmental control / Israel Yu. – L.: Hydromet, 1984 – 500 p.
3. *Holm-Nielsen J.B.* Anaerobic Digestion – Biogas Production./ Holm-Nielsen J.B. Seadi T.Al. //1-st International Ukrainian Conference on Biomass for Energy. – Kyiv. – 2002. – P. 35 – 39.