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### APPROPRIATE TECHNOLOGY FOR LANDFILL METHANE GAS EXTRACTION FOR ELECTRICITY GENERATION AND EMISSION REDUCTION

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#### ABSTRACT

*Landfill Supit Urang Malang has Amount of potential waste to produce Methane gas. Appropriate technology for methane extraction is needed because the only available equipments is backhoe excavator. Flaring Equipment with monitoring system is needed to get the characteristics of methane gas production. Design of equipments and installation of extraction pipe is based on pipe Pile & Betz method. Backhoe Excavator which was used on trial to install the extraction pipe, was less strong to depress the extraction pipe. Pile hammer is then recommended for extraction pipe installation because its ability to install on 700 kg/cm<sup>2</sup> tension of soil but waste only has 200 kg/cm<sup>2</sup>. Methane Gas production is low at night until morning, then increase in morning (about 7 clock) and in the highest production at about 2 clock at noon, with 47 till 55 % of Methane concentration. Produce methane decrease, and go down drastic start at 5 evening, it makes the flaring stop.*

**Key words :** supit urang, backhoe excavator, pile & betz

#### INTRODUCTION

Indonesia implement a new regulation No. 18 year 2008 about the garbage (solid waste) management. The regulation forced local governments to apply sanitary landfill. Implement of sanitary landfill make the emission of methane into the atmosphere are higher than open system or open dumping (Barton, et al., 2007). The alternative solution is to improve the sanitary landfill become methane capture landfill or Methane capture based landfill in framed of Clean development (CDM) project (Masikant, 2006; Masikant, 2008). Methane gas is gas that arises from the anaerobic fermentation process (without air) from organic materials such as livestock manure, garbage, and agricultural wastes. The composition of methane is 80 until 90% and 30 until 50 % carbon dioxide (CO<sub>2</sub>), (Hilman, 2006). Classification based on atmosphere source of methane gas derived from oil and gas industry (45%), solid waste sector (25%), Agriculture (20%), Natural resources (10%) (Domaslaer, 2006; Indartono, 2005).

Waste Supit Urang Malang Landfill has a total estimated 172 040 tonnes in the year 2007. Landfill Supit Urang has four fully charged cell, one cell is operational and one for the next preparation. The landfill has a 491 875 m<sup>3</sup> and 319 580 m<sup>3</sup> of which are still empty. Assumed the place would be filled and closed in 2017, production of waste in that year 39.980.541 ton/ year, the accumulation was

3,151,273,375 tons. The peak methane production is 12,179,626 m<sup>3</sup> per year in 2019. Then the production will decline and will be 14 784 m<sup>3</sup>/year in 2065. These statistics based on formal forecast equation. Some has difference detail information because of the methodology (Fauzan, 2008).

Landfill in Indonesia is currently in general to continue the existing system (open dumping), and few use the sanitary landfill system. From this situation, the model is used for the extraction of conventional models. In the heap of garbage that has been mounting with a height of 10 meters are made in the extraction hole. (Jacobs, 2006; Fauzan, 2008). Excavation using backhoe excavators commonly used in the landfill causing elongated holes, which means there are a lot of work unloading garbage pairs, resulting in wasted of time, effort and cost. Hole with a depth of 10 meters if made with backhoe excavator dig it must be made extra long 10 meters horizontally. Means, it have to spend as much as 50 m<sup>3</sup> of solid waste and garbage after installation shall be refunded. Necessary equipment and appropriate technology for extracting methane gas. It is including method to install extraction pipe at landfills. Design of simple flaring equipment used for combustion of methane gas extraction has been resulted. Flaring equipment need be installed to burn both gas production and monitoring to investigate the characteristics obtained.

# Appropriate Technology For Landfill Methane Gas Extraction For Electricity Generation And Emission Reduction

*by* Turnitin Instructor

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## METHOD

Design methods referenced in this research is to Pahl and Beitz method as described in his book; Engineering Design: A Systematic Approach. This method consists of four phases namely: Planning and explanation of duties; design of product concepts; design of product form (embodiment design) and details design.

Planning phase and explain the task in this research is the formulation as this research, which obtained a prototype design and appropriate technology of methane gas extraction equipment at the place of final disposal of waste. The Limitations of appropriate tools are: Fitting in landfill waste by using hammer as used in the installation of piling. Extraction wells are composed of the extraction pipe with walls perforated holes as gas enters the road. Extraction pipe is enclosed by layers of coral stone with a size of 3-5 cm.

The design phase of product concept implemented by way of literature study and field observation, observations at several landfill so that the resulting products can also be implemented on a landfill with different characteristics. Focus Group Discuss (FGD) held to obtain input and suggestions from colleagues. The end result of this phase in the form of draft/drawing circuit extraction pipe system where all requirements requested on the first phase can be met.

Design phase of product form (embodiment design), in this study was done with form (image) so that the conceptual design looks realistic. At this embodiment design proper materials and dimensions are unknown. Dimensions, materials, and appearance alone are not only confronted with the prediction calculation but also observation result. This phase used the help of software image / drawing / drafting and design in the laboratory of MATC UMM (Muhammadiyah Aplight Technology Center).

The fourth phase is the detailed design. The calculation is done in this phase to produce the dimensions of the design form into three phases. Number of data is required for calculating. The preliminary data obtained from field measurements and observations. In this phase of testing sondir in landfill waste to find out the opponent's force against penetration of soil extraction pipe when installed using a hammer. Based on the design style of the component's point of arrow heads and pipe stem strength to withstand impact or pressure to be channeled to the ground.

Sondir test at some point. This test is to determine the force required to press the "Arrow" model by using

backhoe excavators or other equipment life hitter. The results of this test as well as to obtain soil resistance force that will be used to calculate the angle of the arrow head model. Based on these data, it can be adjusted design drawings. Sondir test well will know the depth of landfill waste. Into the trash it is required to determine the length of the extraction pipe. The procedure used in referring to the ISO 2827:2008.

This standard establishes test methods for penetration of the field with sondir tool, to obtain the parameters of soil penetration resistance in the field, by means sondir (quasi static penetration). These parameters in the form of cone resistance ( $q_c$ ), the shear resistance ( $f_s$ ), the ratio of shear ( $R_f$ ), and the shift of the total soil ( $T_f$ ), which can be used for the interpretation of soil layers that are part of the foundation design.

The output of Pahl & Beitz procedure as mentioned above, are designs in the form of images, which can be communicated to the production unit or workshop production. The outputs are also the pipeline and extraction and flaring equipment. The technical drawing produce in engineering standard, by using Inventor or/and AutoCAD, at the laboratory MATC UMM. In this process was also carried out numerical simulations of constructions. The numerical simulations with vertical axial loading, using finite element method simulation. Making flaring equipment and extraction equipment in two separate workshops. Installation of the landfill.

To attach the pipe extraction or extraction wells at the same time carried out by the following: Making a hole in the heap of garbage at the point of installation; head of the arrow is placed on the hole with the tip downward; done the beating of the base of the extraction pipe to stab into the ground; If the pipe in the shorter the soil surface joined by a new segment and is beating again. These repeat until all the pipes are installed.

Installation of electrical connection between the well / extraction pipe, to collect the methane gas in the extraction of each pipe and then distributed to the flaring (burning engine) or engine generator. The extraction of methane gas is by using a vacuum pump. The methane gas than be channeled into the engine combustor. Discharge and gas pressure is measured/monitored using the data acquisition system. The acquisition system is connected to the computer. Monitoring of gas production, the data are presented in graphs of relationship between time on the axis (hours or days or weeks or months) with gas production in the ordinate.



## RESULTS AND DISCUSSION

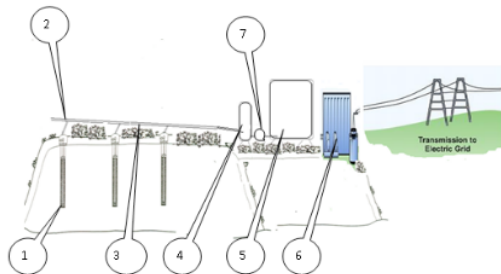
### Concept Product of Methane Capture based Landfill with for Power Station

Taking from the idea of the various patents and literature that have been described above, then at least the design which would have made it the following things:

Extraction well in the form of coal bed methane wells drilled with a rock (1) and perforated pipe. The depth of the well is of 4 to 10 meters. At the top of the extraction pipe, there are special holes for monitoring / measurement; there is a connection to the collector pipe (2). The upper part is placed in boxes to facilitate the process of monitoring and valve settings.

Made a few wells with 25 m spacing between wells, connected with the main collector pipe. Collector pipe is positioned so that water flows tilted downwards, while the methane gas to flow upwards towards the main collector (3). At the bottom of the extraction pipe, is installed to remove water from the canal. Water catcher is installed in places where water blocking feared happened.

Landfill gas (LFG) contains sulfur and dioxin. It has to be removed from the mixture because it can trigger the occurrence of corrosion in diesel. For that gas is passed through the activated carbon filter (4), placed at the end of all collector before the gas is injected into the diesel.



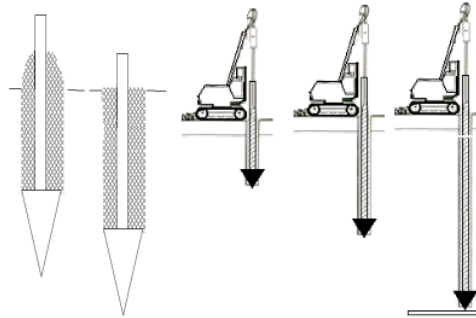
**Figure 1.** A series of Methane And Catcher System Generator

Furthermore, gas is injected into the diesel. Little adjustment is required considering that diesel fuel on the market in general, is liquid is set become employed Methane gas. Diesel used to drive generators to produce electricity. During the operation of various things need to be guarded/controlled in order to keep the machine working, electricity production is stable, and secure is not an explosion. Therefore control system is needed. To maximize and facilitate the production arrangement mounted gas compressor (7) which serves to suck the methane from landfill, then injected into the engine. Device monitoring and

acquisition system are necessary for the purposes of CDM projects and the Prevention of Climate Change.

### Concept Product Vertical Pipe Extraction and Installation

Extraction pipe made in the form of arrows



**Figure 2.** Concept Arrow Model and its installation

Trunk and head made of iron, capable of pressing/ piercing pile of garbage with a suppressor using excavators, or a pile hammer. Surrounding the pipe fill with gravel. If pressed down it into landfill waste and the rock will go into the extraction hole. Pipe and then connected and more stones piled around it and then pressed again. It is done so until it reaches the ground. The pipe diameter approximately 260 mm. The head diameter approximately 600 mm. The length of each segment of the pipe approximately three feet. This size is only initial estimates, it will be revised based on the calculation.

### Embodiment Design

From designing flow charts Pahl and Beitz design phase can be seen that the form consists of several steps, which amount more than the number of steps in the design phase of new product concepts. In the design phase of this form, the concept of product "given form", the components of the product concept in the picture or drawing sketches scheme is still in the form of lines or bars alone, must now be given a form, such that these components together forming the product form, which in its motion does not collide with each other so that the product can perform its function. Product concept that has been described in the preliminary lay out, could get some preliminary layouts.

Preliminary layouts were developed into a better layout by eliminating the existing shortcomings and weaknesses and so forth. Then the evaluation to some preliminary layout has been further developed based

on technical criteria, economic criteria and other more stringent. Definitive layout has been checked in terms of ability to perform the function of the product, strength, financial feasibility, and others.

### Test Sondir

Test parameters sondir produce soil penetration resistance in the field, which is used for the interpretation of soil layers that are part of the foundation design in this case arrow system design, and design of extraction systems. The parameters calculated in sondir test based on ISO 2827:2008 is the way of calculation: cone resistance ( $q_c$ ); shear resistance ( $f_s$ ); shear ratio ( $R_f$ ); shift of the total land ( $T_f$ ), the shear resistance value ( $f_s$ ) is obtained when local cone tip and shear field driven simultaneously. Shear ratio ( $R_f$ ) were obtained from the comparison between the value of local shear resistance ( $f_s$ ) with cone resistance ( $q_s$ ), the total shear value ( $T_f$ ) is obtained by adding the value of local shear resistance ( $f_s$ ) is multiplied by the interval readings.

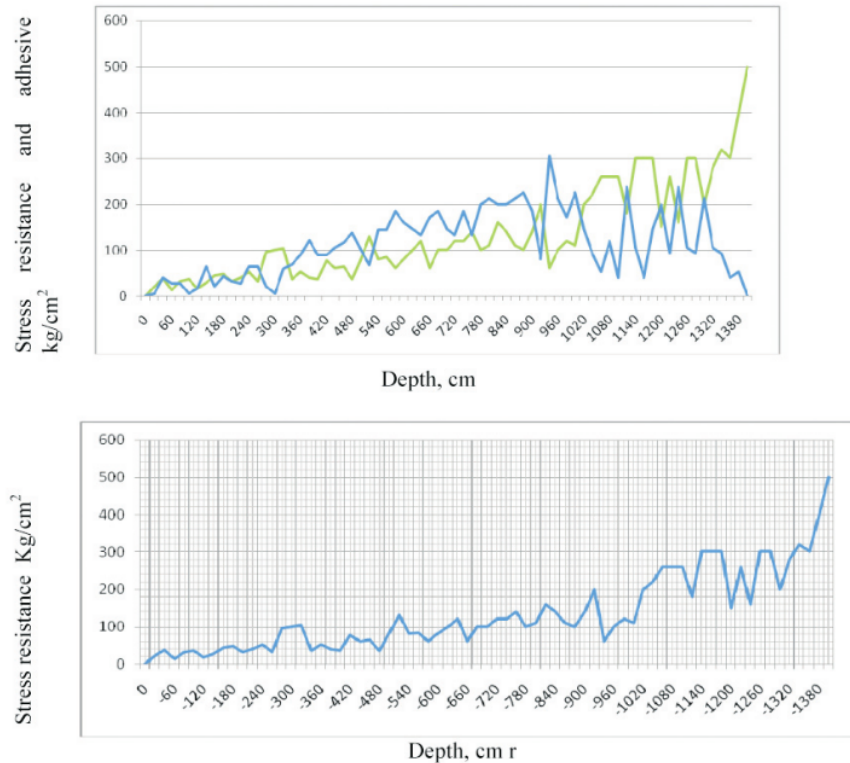
Figure 4 shows the soil resistance to the stabbing of measuring instruments. The more voltage into the

stronger the resistance, it also shows the conditions tested the more landfill waste into the more dense/condensed, to a depth of 10 meters. At a depth of 10 - to 14 m there was significant difference. In that position might be reached the ground hard and not garbage.

On the fifth point of the measured/tested showed that no significant differences in mean congestion garbage at similar positions and also with depth. Gas wells to be installed using the arrow model is 10 meters, up to a maximum of 14 meters. Therefore, preparation of pipe to be installed is 10 to 12 meters.

### Design Adjustments and Production

Arrow model is a name, appears in this study, caused a similar form with arrows. Arrow heads was placed at the lower end as the main component of the urgent land. Selected cross section of the arrow heads are cross-sectional aspect 8. His considerations are more closely circular shape so that has a maximum circumference than the terms under it. Angular form is selected for cross area of the arrowhead be caused,



**Figure 3.** Test Results sondir

if needed to turn around handle bow separately from arrow head, it can be done. If its sectional area in a circle it will be difficult.

When the installation of gas wells conducted, arrow head will be placed at the bottom and then left (not taken back). Awl pipe or rod that used to push the arrow head will function as an extraction pipe. To further save the driver of the pipe was removed and taken back to the extraction pipe is replaced with PVC or HDPE AW. Booster pipe laying pipes will be used for other well with new arrow head.

To ensure that the extraction pipe lagging below, did not participate drawn out, then the lower end of the extraction pipe installed hooks. Arrow head shaped pipe lip County profile adapted to hook the pipe, so that the hook or fastener can get into the pipe arrow head with ease and can be locked easily. The base of the locking pipe connected with PVC pipe or pipes AW extraction. Pipe fastener as shown figure 5 represents the first model of the pipe lock. Another design is the cutting edge extraction or PVC pipe AW Harpoon or hook-shaped rod (Figure 4).



**Figure 4.** Illustration of one extraction pipe lock

Design At the time of installation or when the arrow model extraction wells installed, pushing pipes made segmented with a length of 1.5 meters. This position is intended to make the backhoe excavator has maximum force to push. It is also for simpler / easy mobilization. Long segment is also available to make easier installation.

Top side of the segment of extraction pipe, is the side to be push or hit by using backhoe excavator or pile hammer. This side is prone to experiencing damage or change shape due to the emphasis or force beatings. Change of form, will cause connection difficulty, or difficulty connection to the next pipe. Booster pipe equipped with holes that serves as the entrance of gas. This is if the pipeline will be left behind and functioned as the driving pipe methane gas extraction. Another function of the driving hole on the pipe hole is as a



**Figure 5.** Connection Pipe driver

place to enter the rod holders or rod, as a tool during installation.

### Flaring System

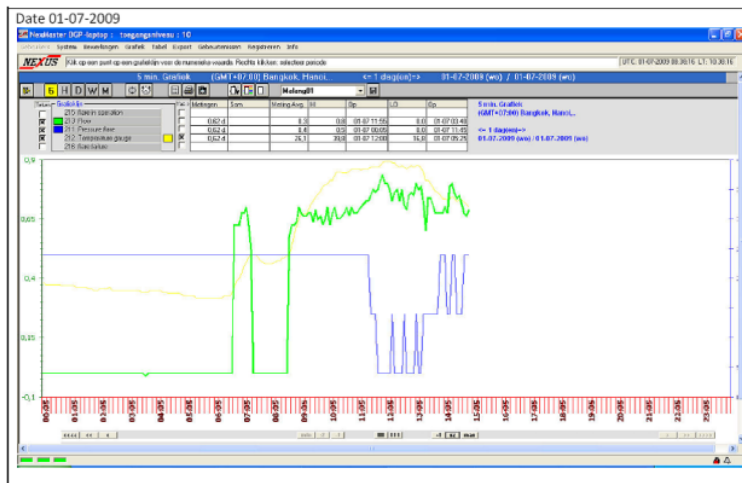
Flaring system in this case is methane gas burner so that landfill gas does not escape into the atmosphere as methane gas but as CO<sub>2</sub>. Flaring system consists of several main components: solar power plants; Control and measuring the flow of gas; burner system; data acquisition system and an internet connection. This Internet connection is coupled with internet network system so the data and flaring system activity can be monitored via the internet, with the appropriate software.

At the top of the extraction pipe, on the surface of the landfill, Head of wells is mounted. Designation for an accessory that is placed on top of the extraction wells. In the accessories have cap/ head, which can be opened and closed, used to monitor water levels of leachate. Leachate water levels should be monitored so that maintenance actions can be performed as required. Too high water or leachate in the well cause the entrance gas holes be covered with water. The water will block the flow of landfill gas into the pipe. Thus causing gas extraction is stooped.

Experiment connections extraction system and flaring system can be done well. This means that produces methane gas extraction wells that resulted in the burning of methane gas flaring system. Monitors system is one of the prerequisites for a CDM project. It recognized ingenerate Emission Reduction Certificate. Examples of the monitoring results are shown in the picture.

Production of methane gas a little at night until the morning, improved production began at 7 am and a peak around 2 pm and then decreased. Methane production decreased dramatically starting at 5 pm with the concentration reaches 47 to 55. Methane producer bacteria are working fine on the





**Figure 6.** Graph monitoring flaring process

proper temperature 40 to 60 degrees centigrade. At temperatures that are too high or too low methane gas production will be reduced. Recommendations from this are that if the bias temperature is maintained within a temperature 40 to 60 degrees centigrade, the methane gas production will take place optimally. Recommendation to control this, is the using of body layer in the landfill to cover the critical thickness of insulation thickness. Covering landfill with clay or soil is advised to in the area Supit Urang Malang landfill. Clay layer can function both as an airtight layer. Airtight is necessary to keep the waste gas extraction equipment on high methane concentrations.

## CONCLUSION

Getting the design and prototyping of methane gas extraction system and technology of vertical drilling/ installation based on the existing equipment and worker safety. Getting the design and prototype of interconnection between methane gas extraction with existing extraction system. The design has been produced and tested a prototype installation of the landfill.

Installation is considered more secure because the worker is not required for entry into the excavation pit. The system of the result research is more efficient and faster because it does not need to dig in wide sizes. It doesn't need to dig some trash to the surface and then when done to return back, but enough with the thrust arrow model to use a back hoe excavator. Back hoe excavator utilization becomes important because of the unavailability or a digger drill vertical holes are able to make vertical hole with size 15-meter depth. Almost

all of the landfill in Indonesia has a backhoe excavator so that this equipment can be empowered.

Backhoe excavator, in this experiment, it was not strong enough to suppress the driving pipe, at a depth of 6 meters of the speed reduction of approximately 1 cm per minute. Recommended for extraction pipe installation should use the pile hammer, a hammer is usually used for the installation of piling. The ability of this hammer can install piles on the ground stress 700 kg/cm<sup>2</sup> at 200 kg/cm<sup>2</sup>. Production of methane gas a little at night until the morning, improved production began at 7 am and a peak around 2 pm with the concentration reaches 47 to 55 and then decreased methane production, and decreased dramatically starting at 5 pm

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