Review Article

DEVELOPMENT OF FLUE GAS TREATMENT UNIT FOR PACKAGED GASOLINE GENERATORS.

ABSTRACT

A review on the Development of Flue Gas Treatment Unit for Packaged Gasoline Generators is reported. Due to shortfall in power supply from National Grid of most developing nations, most businesses relied on package generators for electrical power delivery for their economic activities. Flue gases containing CO and CO_2 were being released into the environment by these fossil fired package generators. The CO is known to be detrimental to health of living beings and at the same time ozone layer depletive. On the other hand, the CO_2 has been contributing to the green house effects. These militating dangers/risks arising from the usage of these package generators strongly informed this review exercise. The level of attendant risks associated with the usage of the package generators was identified. Arrays of control and management methods of flue gases (CO and CO_2 inclusive) were identified and selection options for the design and fabrication of the CO and CO_2 capturing unit were enumerated. Analytical tools were equally highlighted. Significance and efficiency of the design is justified/verified by the analytical outcome.

KEY WORDS: CO Poisoning, Ozone Layer, Green House Effect, Package Generators

INTRODUCTION

Problem Overview

By the end of the 20th century it was widely accepted that carbon dioxide and several other gases are involved in physical and chemical processes in the earth's upper troposphere and stratosphere that may result in global climate change.[1]Arrhenius in 1896 forecasted rising global temperatures as a result of fossil fuel combustion.[1] So-called green house gases (GHG), most importantly Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O) trap the outgoing solar radiation that is reflected by the earth's surface, which leads to global warming.[1] Although the most abundant greenhouse gas in the atmosphere is water causing approximately 2/3 of the greenhouse effect, the result of increasing concentrations of GHGs that cause the other approximately 1/3 is referred to as the "enhanced greenhouse effect", or, since it is primarily the result of human activities, the "anthropogenic greenhouse effect".[1] Consequent on the fore going therefore, various regulatory organs the world over have taken various initiatives to arrest this green house effect.

In order for society to meet up with its energy demand, various forms of energy sources have been harnessed by mankind: ranging from the use of fire wood, thermal power plants, nuclear power plants to fuel oil and gas power plants. Most of these power plants are fired by fossil fuels which give CO_2 and CO as by- products of combustion amongst others. CO_2 in particular has been identified as the most important green house gas. Various efforts are being made and several actions are being taken by the global regulating bodies to control and limit the emission of CO_2 and other green house gases. These efforts that focus on design /capture concept are not extended to the gasoline package generators. In the developing countries, the package generators which are actually designed as standby generators now play the function of source of main power supply for businesses and homes. The attendant implications are that CO and CO_2 are being indiscriminately emitted into the environment to the detriment of health and global warming which could result from the greenhouse effect. Consequent on the foregoing some action plan is required to arrest this indiscriminate pollution of the environment arising from the gasoline package generators' emissions among others. Here lies the justification for this research.

Generators are devices that convert mechanical energy to electrical energy. The design of such generators range from extreme large structures such as turbo-generators as in thermal power plants, nuclear power plants, hydro power plants, geothermal power plants, Brown gas generator, wood gas generator, wind and tidal power plants to package units used in the home, emergency and leisure as standby sources of power. Generators could be classified according to source of energy, hence we have thermal generators, geothermal generators, hydro generators and solar generators. Also generators could be classified based on the source of fuel: such generators include natural gas generators, gasoline generators, diesel generators, brown gas generators and wood gas generators among others. Such package generators are variously referred to as portable generators, portable electric generators, portable power generators, portable power generators, home standby generators, commercial generators and marine generators.[2] The power range for a variety of these package generators varies from about 800watts to 15 kilowatts.[2] These generators are marketed in various names, according to the manufacturers and marketing outfit. A few of such names include: Honda, Yamaha, Norwall power systems, Binatone, Firman, Elemax and Tiger.

The energy and power delivery to the economies of the developing nations has been dwindling over the years. The quality of power generated , that is supply relative to demand has been on the decline, even in the face of new power stations coming on stream the National Grid. This short fall in meeting the National demand has been so severe that virtually all serious business concerns have to procure one form of generating set or the other in order to guarantee the smooth continuity of their businesses.[3]

The brand of these generators that are fossil fuel fired release flue gases into the environment. Flue Gas has been defined as gas that exits to the atmosphere via a flue which may be a pipe, channel or chimney for conveying combustion product gases from a fireplace, oven, boiler or steam generator.[4]Flue gases are produced when coal, fuel oil, natural gas, wood or any other fuel is combusted in an industrial furnace or boiler, a steam generator in a fossil fuel power plant or other combustion sources.[4]Flue gases have also been defined as byproducts of combustion which are classically vented through long pipes known as flues.[5] These gases are treated as pollutants. Flues can be referred to as “stacks”, and they may be found in the form of chimneys, ducts, or simple pipes. Large amount of flue gases are generated around the world on daily basis, with heavy industry and the power industry in particular being responsible for a huge percentage of the total generated. The contents of flue gases are quite variable. The medium being burned can contribute a number of different compounds, and the conditions under which combustion is occurring can also generate more or less emissions. Incomplete combustion at low temperatures or in poorly managed facilities, for example, tends to generate more pollution.[5] Some things commonly found in flue gases include: water vapour, carbon dioxide, nitrogen, particulates, oxygen, carbon monoxide, nitrogen oxide, hydrocarbons, and sulphur oxide. Some of these compounds are potentially harmful for the environment, making these gases an issue of concern among environmental advocates. Flue gases can also be hazardous for human health, as might occur if they were trapped in an air inversion which pinned them close to the ground for several days, forcing people in the area to inhale hazardous pollutants which could damage their lungs.[5]

There are a number of ways in which flue gases can be controlled, and the processes which produce flue gases are often heavily regulated to force emissions levels down. One of the best methods for control is to avoid generating them at all, either by using alternative technology, improving efficiency levels at a plant, or studying ways in which operating conditions could be improved to reduce the production of combustion by products.[5] Gases which cannot be prevented can be trapped using filters and scrubbers which clean the air coming out of flues so that when it is released into the environment, it contains primarily harmless components.[5] Scrubbing flue gases can even be profitable for a savvy company. For example, the food industry has a use for carbon dioxide, and is willing to pay for purified carbon dioxide extracted from flue gases. This use also resolves the problem of what to do with pollutant once it has been removed from the flue. Emissions at flues are routinely tested to determine whether or not the gases are being adequately scrubbed before they are vented into the environment.[5]

Greenhouse Gases, Ozone-Depleting Gases.

By the end of the 20th century it was widely accepted that carbon dioxide and several other gases are involved in physical and chemical processes in the earth's upper troposphere and stratosphere that may result in global climate change.[1]Arrhenius in 1896 forecasted rising global temperatures as a result of fossil fuel combustion.[1] So-called green house gases (GHG), most importantly Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O) trap the outgoing solar radiation that is reflected by the earth's surface, which leads to global warming.[1]Although the most abundant greenhouse gas in the atmosphere is water causing approximately 2/3 of the greenhouse effect, the result of increasing concentrations of GHGs that cause the other approximately 1/3 is referred to as the "enhanced greenhouse effect", or, since it is primarily the result of human activities, the "anthropogenic greenhouse effect".[1]Several other gases such as Nitrogen Oxides (NO_x = NO + NO_2), and non-methane VOCs (NMVOCs) such as ethane, CO, Tetrachlorocarbon (CCl_4) and Chlorofluorocarbons (CFCs) are recognized to be ozone-depleting substances (ODOs), that is, substances that do not have a global warming effect but influence the formation and destruction of tropospheric ozone.[1] This may explain the so called ozone holes over the arctic and Antarctic poles. The ozone layer is crucial for many forms of life on earth by blocking "hard" ultraviolet solar radiation. Carbon dioxide is a major product of hydrocarbon combustion and is also found in gasification product gases. Concentrations in flue gases from power plants is approximately 4% volume CO_2 for natural gas fired combine cycles (NGCC), approximately 9% volume for coal fired IGCC and approximately 14% volume for pulverized coal-fired boilers. It is also present in natural gas, from which it has to be removed down to typically 2.5% volume to meet customer specification.[1] In the same vein, there is an increasing concentrations of CO_2 and CH_4 in the atmosphere and this is correlated with world population, dating back over long periods by using experimental data from for example air trapped in polar ice.[1] CO_2 concentrations started to rise about 1800 and are currently increasing at approximately 1% annually, from about approximately 355ppmv in 1990 to approximately 380ppmv in 2000. Noticeable increases in CH_4 concentrations are also seen, increasing at approximately 0.5% annually from 1.7ppbv in 1990 to approximately 1.8ppbv in 2000. Similar trends are seen for the other GHGs and the ODs. CO_2 is responsible for approximately 72% of the enhanced greenhouse effect. The combustion of hydrocarbon fossil fuels is the major reason for this.[1]GHG emissions data from the US from the 1990s given in Table1,shows that fluorocarbon species have minor contributions, appointing 80-85% to CO_2.[1] This table also gives the so called global warming potentials(GWPs) for six leading GHGs that are under discussion in international climate change negotiations. Taking carbon dioxide as a reference with GWP =1, the other GHGs show higher values due to a different radiation absorption behavior and a different life time in the atmosphere. Especially the synthetic GHGs such as the HFCs (which contain H, F and C), PFCs (which contain F and C) and SF6 are very stable and persistent.[1]

Table 1- Six Greenhouse Gases and Their Emission in the Us in 1990 And 1998

GHG COMPOUND	GLOBAL WARMING POTENTIAL(GWP)	% OF US GHG EMISSIONS(1990)	% OF US GHG EMISSIONS (1998)
Carbon dioxide, CO2	1	Approx. 85	Approx. 81
Nitrous oxide, N2O	310	Approx. 2.5	Approx. 7
Methane, CH4	21	Approx. 12	Approx. 10
Hydrofluorocarbons, HFC	140-11700	< 1	< 1

Perfluoro carbons, PFC	7400	< 1	< 1
Sulphur hexafluoride, SF6	23900	< 1	< 1

Source: Zevenhoven and Kilpinen(2001).

Table 2 Us Greenhouse Gas Emissions 1998: Three Most Important Sources per GHG Type

CO2	Fossil fuel combustion industry approx. 32%	Fossil fuel combustion transportation approx. 30%	Fossil fuel combustion residential approx. 20%
CH4	Landfills approx. 33%	Fermentation approx. 19%	Natural gas systems approx. 19%
N2O	Agriculture and Soil management approx. 70%	Mobile combustion sources approx. 14%	Nitric acid production approx. 5%
HFCs, PFCs, SF6	Substitution of ozone-depleting gases approx. 36%	HCFC-22 production approx. 27%	Electrical transmission and production approx. 17%

Source: Zevenhoven and Kilpinen(2001).

Controlling the CO_2 emissions from fossil fuel combustion will have the largest impact on the GHG emissions; and that large-scale, stationary sources such as power plants and industrial utility boilers, accounting for approximately 1/3 of the fossil fuels- derived CO2 emissions may be the easiest to control; and that transport vehicles may be converted to run on electricity or hydrogen, whilst residential heating maybe accomplished with district heating systems or heat pumps.[1]

Carbon Dioxide Emissions Reduction, Capture and Storage

Emissions of carbon dioxide are an inevitable result of hydrocarbon fuel combustion for power and electricity generation. This depends partly on the C/H ratio of the fuel: per unit power the CO_2 emissions from CH_4 combustion are less than for coal or lignite. And more efficient processes will produce less CO_2 per unit power generated (for example CO_2/KWh electricity); Gas turbines are more efficient than condensing steam plants.[1]

The CO_2 emissions per KWH power generated from a low efficiency coal- or lignite –fired boiler may be 4 times those from a natural gas fired gas turbine combined cycle plant (NGCC).[1]Even if a maximum concentration of 500ppm CO_2 in the atmosphere would be as a limit, an emission reduction of approximately 40% has to be achieved by the year 2025, which cannot be achieved by higher increasing energy efficiency alone.[1]Since fossil fuel firing will be the major heat and power source for many years to come, the capture and storage of CO_2 from flue gases cannot be avoided, if such significant emission reductions are enforced as demonstrated by the analysis done by Gottlicher in 1999 as an example of five approaches to CO_2 retention or "Sequestration" from fossil fuel-fixed power plants as listed in Table 3.[1]

Table 3 – Options for CO_2 Emissions Control From Fossil- Fired Power Plants

PROCESS TYPE	CO_2 EMISSION CONTROL METHOD
Gasification and CO/water shift	Removal from fuel gas before gas combustion
Conventional combustion	Removal from flue gas.
Combustion in O_2/CO_2	Removal of water from flue gas, gives CO_2
Fuel cells	Removal after fuel reforming or from off gas
"Hydrocrab" etc	Removal of Carbon from the fuel before combustion.

Source: Zevenhoven and Kilpinen (2001).

Citation of the works of Lyngfelt and Leckner in 1999 led to the conclusion that the separation of CO_2 from flue gas or fuel gas will be the least costly option but nonetheless rather expensive.[1] Removal of CO2 from flue gases or from gasification product gases has a negative effect on the energy efficiency of the power plant. These losses vary from 7 to 14 percent points and are higher for plants with lower efficiencies.[1

Table 4 – Effect of CO_2 Removal on Power Plant Emissions and Efficiency

PROCESS	CO_2 CAPTURE	EFFICIENCY(% LHV)	CO_2 EMISSIONS(g/KWH)
Natural gas CC	-	56	370
	After combustion	47	60
	After CO/shift	48	60
Pulverized coal combustion	-	46	720
	After combustion	37	150
Coal IGCC	-	46	210
	After CO/shift	38	130

Source: Zevenhoven and Kilpinen(2001).

The removal of CO_2 from gases is standard procedure for natural gas upgrading, usually in combination with H_2S removal (Sour gas stripping), chemical or physical sorbents can be used for large gas volumes and /or high concentrations of CO_2. Other methods are adsorption on alumina, activated carbon beds or zeolites, membrane separation or cryogenic methods.[1] For selective removal of large amounts of CO_2, physical and chemical sorbents are the options. For a chemisorptions process, the suitable solvents are: MEA (mono-ethanol amine), DEA (di- ethanol amine), ammonia potassium carbonate; for physisorption, the most important processes are the selexol process which uses DMPEG (di-methyl ether of polyethylene glycol), the puriscol process using NMP(N-mthyl -2-pyrrolidone) or the Rectisol process based on cold methanol.[1]

For power plant flue gases treatment, disadvantages of chemical and physical sorption processes for CO_2 removal are that SO_2 and NO_2, if still present in the gas, react with chemical sorbents which leads to solvent losses.[1] SO_2 is very soluble in physical sorbents such as selexol and cannot easily be recovered. After capturing the CO_2 from power plants, the more serious problem of long-term disposal or storage arises. Five options that are currently considered feasible from an economic as well as an environmental point of view are: [1]

1) Deep ocean storage
2) Depleted oil/gas fields
3) Enhanced oil recovery (EOR)
4) Un-mineable coal beds and
5) Deep saline reservoirs and aquifers.

On the other hand, several other options that are considered unattractive from economical point of view are storage in underground caverns, as solid dry ice and as mineral carbonates.[1] This last option however is receiving continued attention because of its tremendous potential: enormous natural resources of minerals would be able to fixate CO_2 as mineral carbonates.[1]

Recovery of CO_2 from Flue Gases: Commercial Trends

The interest in recovery of carbon dioxide (CO_2) from flue gases is being propelled by multiple factors: the merchant CO_2 market, renewed interest in enhanced oil recovery (EOR) and the desire to reduce greenhouse gas emissions.[6] A review of the latest operating and capital cost data for the Flour Daniel Econamine FGsm Process and recap of the key process design and operating issues for amine chemical solvent CO_2 recovery processes portrayed the competitive processes for CO_2 recovery from flue gases. According to the authors, the Econamine FG Process has proven reliable operations with both natural gas and fuel oil-derived flue gases in plants ranging in size from 6 to 1000tonne/day CO_2 and in pilot plant operation with coal-derived flue gases.[6] No flue gas CO_2 recovery process can presently compete with by-product CO_2 where it is available in sufficient quantity.[6] However, where by-product CO_2 is not available, or if the merchant price of crude oil remains at its present levels, the Econamine FG Process and other similar competing processes will again be economically viable.[6] The largest potential market for CO_2 is the EOR. The major CO2 sources that can be considered for the EOR market are:[6]

Natural Sources --- CO_2 wells

Industrial by-products -- Natural gas sweetening, synthetic gas production

Flue gases -- Fossil fuel-fired power plants, Industrial furnaces; Cement plants; engine exhausts and line kiln exhausts.

In a similar vein, recent technological development have made it realistic to use fossil fuels to generate heat and electricity without CO_2 emissions, or with marginal emissions only.[7] Dongenergy is joining forces with large number of European partners to participate in a project aimed at developing technology that can absorb CO_2 from flue gases; and that the project is called CASTOR and funded in part by the EU.[7] Capturing CO_2 from flue gases is not a difficult process, but the challenge is to find a so-called absorbent that can absorb CO_2 at the temperatures at which it is emitted.[7] The temperatures required by today's absorbents are so high that the flue gases have to be heated to allow absorption. The goal is to eliminate the costs associated with heating these gases. The author further posited that the project also investigates the potential for using the captured CO_2 to optimize offshore oil production.[7] Injecting CO_2 into mature oil fields can increase the percentage of recoverable oil.[7] The technology has the potential of reducing CO_2 emissions from coal-fired electricity and heat-generating plants as well as increasing offshore oil production, hence solution to more than one problem.[7]

While discussing the gas clean up for power plants and waste incinerators/effects of emission control on emissions and emission control for other species it is observed that:[8]

a) In nitrogen species emission control: effect on other pollutants: low NO_x methods may increase CO and carbon- in-ash
b) In halogen and dioxins/furans emission control: effect on other pollutants: chlorine and other halogens hinder CO burn out.

With the rising oil prices, wood gas generators are generating a renewed interest.[9] The US Federal Emergency Management Agency (FEMA) published a book, Construction of a Simplified Wood Gas Generator for fueling internal combustion engines in petroleum emergency in March 1989.[9] A project about the energy future of Europe was begun in 2005 in Gussing, Austria with contribution of European Union research furtherance.[9] The project consisted of a power plant with a wood gas generator and a gas engine to convert the wood gas into 2MW electric power and 4.5MW heat. The advantages of the wood gas generator are as follows:[9]

i) They can be used to run internal combustion engines (or even gas turbines, for maximal efficiency) using wood, a renewable resource, and in the absence of petroleum or natural gas, for example, during a fuel shortage.
ii) They have a closed carbon cycle, contribute less to global warming, and are sustainable in nature.
iii) They can be relatively easily fabricated in a crisis using materials on hand.
iv) They are far cleaner burning than, say, a wood fire or even a gasoline-powered engine is (without emissions controls), producing little if any soot.

The disadvantages of wood gas generators are: large size, relatively slow starting speed and batch burning operations, that some designs feature.[9] Also, one of the primary combustible fuel-gases produced during gasification is carbon monoxide: it is an intentional fuel- product, and is subsequently burned to safe carbon dioxide in the engine(or other application) along with the other fuel-gases; however, continuous exposure to carbon monoxide can be fatal to humans even in small to moderate concentrations.[9]

In a similar note, a natural gas generator is more economical to use than petrol fueled generators.[10] It is also environment friendly to operate because it minimizes the probability of polluting the immediate and surrounding area where it operates.[10] According to Josh (2010), natural gas generators burn cleaner too, producing no fumes compared to a lot of toxic fumes produced by gasoline engines. In the words, Natural gas is the cleanest burning fossil fuel. It emits much lower levels of sulfur, nitrogen and greenhouse gases and is more economical to use saving as much as 40% lower compared to diesel and gasoline engines.[10]

Brown gas is obtained from a process which develops a “gas” from ordinary water invented by Yull Brown(originally of Hungary) later of Australia and now deceased.[11] The flame of this gas under the right lighting conditions, normally almost transparently colourless, can be seen to possess a small blue cone , as it emits from a torch, with a longer, pale red-blue extension. Within its overall sheath are several distinct regions called “mantles”. The most unusual property of the flame is that it is not formed as a set of explosions, as are ordinary flames, but as a set of implosions. Consequently, all classical theory about combustion products, highest temperature regions, and other specifics are up for revision. It is in the central blue cone of the flame, as opposed to its extension that the novel combustion is sustained.[11]

The technology of producing a stoichiometric gas from an advanced alkaline electrolysis process as developed by Yull Brown has many clean and efficient applications, especially for heating, cooling, clean water production, water as an engine fuel and energy storage.[12] Brown gas is water separated into its 2 constituents by an advanced alkaline electrolysis process in a way that allows them to be mixed under pressure and then be burned together and safely in a 2:1 proportion. The process results in a gas containing ionic hydrogen and oxygen. When sparked, the gas recombines safely, by implosion, into water, collapsing in a vacuum/water ratio of 1886.6/1.[12] Three decades of research by the inventor, Yull Brown , an Australian citizen, have yielded numerous applications for the gas, namely: production of electricity among 26 six varied uses identified.[12] There is also the very convincing, but not yet test-proven on a large scale, case of using Browns gas for the purpose of storing energy in such situations as excess hydro capacity, wind and solar energy by producing Browns gas from electrolysis during slack demand periods and then using Browns gas to produce electricity during high-consumption periods.[12] The ready and limitless availability of water makes Browns gas possibly the best carrier for solar energy and other alternative energy sources developed to this time.[12] It has higher energy conversion efficiency than hydrogen alone, which is conventionally considered to possess the highest conversion efficiency as fuel. Brown gas is non –polluting--- it does not even emit the nitrogen oxides, which results from hydrogen burning. It is naturally recyclable--- the product of its burning is pure water. Brown gas is adaptable, like hydrogen, to most of the existing energy utilization technologies, without any major modifications.[12]

It Can Generally Be Summarized That The Following Holds:

1. Generators are devices that convert mechanical energy to electrical energy.
2. Power supply from National grid of most developing nations (Nigeria inclusive) is insufficient for economic activities.

3. Consequent on above, most businesses rely on package generators for electrical power delivery.
4. All generators that are fossil fuel fired release flue gases into the environment.
5. Most flue gases contain CO and CO_2. The CO is detrimental to health of living men and animals and at the same time depletes the ozone layer. On the other hand the CO_2 contributes to the greenhouse effect.
6. Consequent on the above, World Health and Environmental regulating bodies have taken initiatives to regulate and reduce the emissions of these gases to as low as reasonably possible (ALARP).
7. Efforts are being made to develop purifying/capturing methods for these green house gases while at the same time seeking alternative renewable energy sources to replace energy sources that generates the green house gases.
8. Most of the improvement efforts on energy sources that are safe and efficient in usage have been geared towards grid equipment such as turbo-generators, boilers, industrial furnaces, geothermal, hydro and solar energy.
9. Identified methods of capture of CO and CO_2 include the absorption of the gases using either the wet or dry methods.
10. Different storage and discarding methods were identified as means of managing the captured gases.

The efforts and improvements made in the capture of CO and CO_2 were never targeted at the gasoline package generators. This appears to be an oversight in the sense that the package generators in the first instance were not actually designed as full time generators. Rather, they were designed to serve as standby and emergency units. But the acute deficit of power supply to economic businesses in developing nations and coupled with poor finances, have compelled the businesses to resort to usage of package generators as main power source. This has led to ample generation of CO and CO_2, the ODs and GHGs abundantly in the developing countries. Since the use of fossil fuel will remain with us for a long time to come, the need therefore arises for improvement action to be taken in minimizing the emission of the OD and GHGs from the package generators into the environment.

MATERIALS AND METHODS

Materials

Flue gas treatment unit, CO and CO_2 gas analyzers and Package Generators

Methods

1. CO and CO_2 capturing modes/materials identified in the literature review is further investigated to discover the best capturing materials.
2. A suitable flue gas treatment plant/unit should be designed, fabricated and tested. CO and CO_2 gas analyzers are used for measurements.
3. Test data is analyzed to establish if any relationship exist between power generated, captured CO and CO_2 and the efficiency and safety in usage of the gasoline generator.
4. Consequent on 1 to 3 above, inference is drawn.

Analytical Tools

Basic hypothetical position is taken as**:**

Ho_1- it is not likely that suitable capturing method for CO and CO_2 in flue gas of gasoline package generator will be identified.

Ho_2 - is not likely that a suitable and functional CO and CO_2 capturing plant/unit will be designed/fabricated for the gasoline package generator.

Ho_3 - it is highly unlikely that the design for CO and CO_2 capturing will be efficient and safe in usage.

The analytical tool to be used is the Multiple Regression Method (MRM) of the form:

$$Y = b_o + b_1x_1 + b_2x_2 + b_3x_3 + u \quad (1)$$

Where x_1 and x_2 represent captured CO and CO_2 respectively, x_3 represents power generated and Y the efficiency of the gasoline generator.

Test Of Significance

(A) t-TEST

To test the null hypotheses.

H_o: $b_j = 0$ (j = 0 to 3) against the alternative hypothesis.

H_a: $b_j \neq 0$

If n< 30, we reject H_o if

$$T = |b_j/s_{bj}| > t_{\alpha/2,\ n-k-1} \quad (2)$$

(B) F- STATISTICS TEST

The F- Statistics is defined as

F = [(Total Explained Variation)/K]/[(Total Unexplained Variation)/(n-k-1)]

Where k denotes the number of independent or explanatory variables in the regression and n the number of data observations. In terms of coefficient of determination, F- Statistics can be calculated as follows:

$$F= (R^2/K)/[(1 – R^2)/(n-k-1)] \quad (3)$$

The F- Statistic is used to test whether a significant proportion of the total variation in the independent variable has been explained by the estimated regression equation. The hypothesis actually being tested is that the dependent variable in a regression equation is statistically unrelated to all of the independent variable included in the model. If the hypothesis is true, the total explained variation in regression will be quite small or zero at extreme.

Thus, if F = F-Statistics from experimental results and

$F_{\alpha,k,n-k-1}$ = Critical value of F – Statistics from F- Distribution Table,

If $F – F_{\alpha,k,n-k-1} > 0$, Reject the Null Hypothesis H_o and accept the alternate Hypothesis.

If $F- F_{\alpha,k,n-k-1}< 0$, Accept the Null Hypothesis H_o. (4)

DISCUSSIONS

The power shortfall scenario facing the businesses in the developing economies is likened to being between the devil and the deep blue sea. This is as much so because no enough power is available at the National Power Grid and on the other hand, businesses cannot shut down on the account of poor power delivery from National Power Grid. Hence for the Businesses for now there is no alternative to the package generator. Therefore, the attendant noise and flue (CO and CO_2 inclusive) pollution will be with the society for a long time to come. The immediate and urgent thing for now is to mitigate and embark on some control measures to limit this pollution to an acceptable statutory level. Hence in the design and fabrication of the CO and CO_2 capture unit, emphasis is placed on the absorption of the gases using either the wet or dry methods. Among the arrays of discarding methods identified for the captured gases, some form of sequencing is done to align capturing process to discarding process in order to optimize the overall system. The analytical tools will evaluate and justify the efficiency and effectiveness of this project effort through the significant, F-Statistic and Regression tests. The outcome of this project effort will keep the environment safer and put more money in the pockets of business units, as the environment becomes cleaner, neater and safer hence minimized environmental and pollution litigations fines and expenses. Also the health and medical bills will drop.

CONCLUSION

The impact of high concentration of CO to human life is lethal and should not be treated with kid gloves. This severity index is more than enough justification for action to be taken to minimize the attendant scenario that leads to the over generation of CO. all efforts directed towards limiting the indiscriminate and uncontrolled generation of CO and CO_2 is a welcome development. The review identified hazard levels of CO and CO_2, the attendant design process of the CO and CO_2 capturing units and the discarding and management of the captured CO and CO_2 constitute contribution to the body of knowledge and environmental safety. This research will be contributing to the body of knowledge by verifying some of the suggested techniques/claims for managing flue gases and also keeping the environment safe through the reduction of CO and CO_2 discharge into the atmosphere. Note that CO_2 is the most important green house gas.This work is by no means conclusive as a final arbiter. Rather, it forms a bridge or spring board for further investigation.

REFERENCES

1. Zevenhoven R, Kilpinen. Green House Gases, Ozone –Depleting Gases. 2001. Accessed on Google 31/12/2010. Available:www.abo.fi/-rzevenho/gasbook.html
2. Norwall. Norwall Power Systems. 2010. Accessed on Google 31/12/2010. Available: http://www.norwall.com/index.php?cpath=17..
3. Okpighe, SO. The Effect of Engineering Safety Inspection On The Success of The Power Holding Company of Nigeria's Rehabilitation Projects in The Journal of Engineering And Design. . Rosefelt Academic Publications. July 2009; 1(1)Vol. 1 No. 1.. Port Harcourt, Nigeria. rap@gmail.com
4. Citizendium. Flue Gas---- Encyclopedia Article. 2010. Accessed on Google. 20/12/2010. Available: http://en.Citizendium.org/wiki/Flue_gas..
5. Wisegeek. What Are Flue Gases?. 2010 Accessed on Google 31/12/2010 Available: http://www.wisegeek.com/what-are-flue gases.htm.
6. Chapel D, Ernest J and Mariz C Recovery of CO2 From Flue Gases: Commercial Trends in Conference Proceedings of Society of Chemical Engineers Annual Meeting. Canada. October 4 -6, 1999. Saskatoon, Saskatchewen. Accessed on Google 31/12/2010 Available: www.netl.doe.gov/publications/proceedings..
7. Dongenergy. Reducing CO_2 in Flue Gases. 2010. Dong Energy A/S Kraftvaesksvej 53 Skaerbaek- 7000 Feredericia, Denmark. Accessed on Google 31/12/2010. Available:http://www.dongenergy.com/en/business%20activities/research---.
8. Zevenhoven R, Kilpinen. Cross Effects and Total Gas Clean-Up System Layout in e-Book Control of Pollutants in Flue Gases And Fuel Gases. Course ENE-47.153 for The Helsinki University of Technology. ISBN 951-22-5527-8. 2001.Accessed on Google 31/12/2010. Available: www.hut.fi/-rzevenho/gasbook.
9. Wikipedia. Wood Gas Generator. 2010. Accessed on Google 31/12/2010. Available: http://en.wikipedia.org/wiki/wood_gas_generator. .
10. Josh K J. "Natural Gas Generator – Your Economical and Environment Friendly Electrical Energy Source". 15 November 2010. Accessed on Google 31/12/2010.

Available:http://ezinearticles.com/?Natural-Gas-Generator.

11. Svpvril. Browns Gas. 2010. Accessed on Google 31/12/2010 Available:http://www.svpvril.com/svpweb9.html.

12. Michrowski A. Water As A Fuel- Browns Gas. 2010. Accessed on Google 31/12/2010 Available: http://www.svpvril.com/svpweb9.html..

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