Global Journal of Engineering and Technology Advances

eISSN: 2582-5003

Cross Ref DOI: 10.30574/gjeta

Journal homepage: https://gjeta.com/

(Research Article)

Check for updates

Improvement of the exhaust fume influence on environment through magneto hydrodynamic system

CO IGWEH [1, *] and BO UGWUISHIWU [2]

[1] *National Center for Energy Research and Development, University of Nigeria, Nsukka, Nigeria.*
[2] *Department of Agricultural Engineering, University of Nigeria, Nsukka, Nigeria.*

Global Journal of Engineering and Technology Advances, 2023, 16(01), 064–072

Publication history: Received on 07 June 2023; revised on 16 July 2023; accepted on 18 July 2023

Article DOI: https://doi.org/10.30574/gjeta.2023.16.1.0129

Abstract

In developing countries the need for combustion exhaust reduction is of great concern, since global warming has been associated with burning of fuel. The objective of the work is on carbon emission elimination with the use of Magneto Hydrodynamic (MHD) system. This system was constructed with Alinco magnets of 8200Guass strength and metal construction with steel of gauge 17. The Magneto hydrodynamic system constructed was used to run three sets of tests for sixty minutes taking readings of 0.5minute,1minute, 2minute, 3minute, 4minute, 5minute, 10 minute, 15minute, 20minute, 25minute, 30minute, 35minute, 40minute, 45minute, 50minute, 55minute, 60minute, and the average was taken. The temperature, oxygen output, carbon (iv) oxide, and the efficiency of the exhaust fume from 800watts generator was measured with and without the constructed Magneto hydrodynamics. The results showed a complete elimination of carbon (iv) oxide, an increase in the combustion efficiency from 83% to 87% on the average, an increase in the oxygen produced from 10% to 20% on the average and a reduction of the exhaust temperature from 264.53o C to 109.53o C. It was observed from the result that there was a total elimination of carbon (iv) oxide this implies that it completely removed the produced carbon(iv) oxide from the 800watts generator, therefore it is completely environmentally safe, also the heat reduction of the output shows a recovery of waste heat from the exhaust system, this improving the energy efficiency.

Keywords: Waste heat; Carbon elimination; Environmentally safe; Energy efficiency

1. Introduction

Clean energy is not a single industry instead involves a wide variety of very different industries. Some of the broad sub sectors under clean energy include Solar power, fuel cells, geothermal power, wave/tide power, bio-fuels, cleaner coal, and power efficiency (Asplund, 2008). In Asplund's work the power efficiency sub sector is being considered knowing that the extra inefficient power is a waste both detrimental to the Environment and the Economy. According to Asplund, 'The U.S energy information administration is fully expecting double fuel consumption by 2030.' The simple fact is that burning fossil fuels, whether in power plants or in internal combustion engines, releases CO_2, other greenhouse gases, and various contaminants into the atmosphere, causing pollution and global warming problems. Energy hence needs to be derived from cleaner sources that avoid these problems (Asplund, 2008).

Since the origin of man there has always been a concern for energy production for the purpose of warming, cooking, lighting, etc. This has eventually caused man to develop heaters, turbines, stoves, etc, which have released a lot of harmful gases which are now becoming increasingly uncontrolled (Riebeek, 2010). The Magneto hydrodynamic system has been found to be beneficial in the reduction of these gases from the exhaust of engines.

* Corresponding author: CO IGWEH

Objectives of Study

The objectives of the study are:

- Design and Construction of MHD system.
- Performance evaluation of the MHD system.

2. Literature review

2.1. Brief Definition of Global warming

Scientific understanding of the cause of global warming has been increasing. In its fourth assessment (AR4 SYR, 2007) of the relevant scientific literature, the Intergovernmental Panel on Climate Change (IPCC) reported that scientists were more than 90% certain that most of global warming was caused by increasing concentrations of greenhouse gases produced by human activities. This has generated a lot of interests in different ways and means of reducing this effect of which the Magneto hydrodynamic system is a strong advocate. In 2010 that finding was recognized by the national science academies of all major industrialized nations (Riebeek, 2010).

Human influence has led to warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes. This rise has been solely caused by the excess production of carbon (iv) oxide which this work sort to reduce. This evidence for human influence has grown since 2007. It is extremely likely (95-100%) that human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC AR5 WG1, 2013a).

Earth has been in radioactive imbalance since at least the 1970s, where less energy leaves the atmosphere than enters it. This imbalance has mainly been caused by the excess carbon (iv) oxide and other green house gases. Most of this extra energy has been absorbed by the oceans (Rhein, 2013). It is very likely that human activities substantially contributed to this increase in ocean heat content (IPCC AR5 WG1, 2013b).

- The scale and suddenness of the ozone decline shocked the scientific world, and led to the 1985 Vienna Convention for the Protection of the Ozone Layer and the 1987 Montreal Protocol and subsequent amendments to eliminate certain CFCs from industrial production. As a result of this rapid action the global consumption of the most active gases fell by 40 per cent within five years and the levels of certain chlorine-containing chemicals in the atmosphere have started to decline. It will be decades before the CFCs already in the atmosphere to fully decay (Blue, 2013).

3. Materials and Methodology

The bolts and screw used also were consider because they were strong enough to hold the iron sheet , taking advantage of the smallest possible size of bolt and screw, to minimize both cost and space inside the Magneto hydrodynamic system. The red oxide was used to paint the outside just to beautify it, and red oxide was used because it can withstand heat and harsh environment more than ordinary paint.

Table 1 List of Materials of Construction

S/N	Material	Purpose	Qty
1.	Magnets (5x5 mm)	For the MHD duct	30
2.	Flat Bricks	For insulation of MHD duct	30
3.	25mm Bolts & Screws	To hold magnets	60
4.	Potassium	Catalyst	0.001 Kg
5.	Sodium	Catalyst	0.001 Kg
6.	Iron Sheet (Gauge 17)	For construction of MHD duct and funnel	1 length

7.	Electrode	Welding of the iron sheet	1 packet
8.	Red Oxide	For painting	cup

3.1. Design Goals/Considerations

The design considerations taken were firstly, the energy conservation law in equation 1, which states that for a body in motion to come to rest the must be a repelling force (friction), hence this force converts the energy of the exhaust fume in kinetic form represented by the density multiplied by the velocity of the exhaust fume (ρu), into heat as represented by the change in temperature multiplied by the density of the exhaust fume (∂t ρ). This forms the basis of the Magneto hydrodynamic system, since the main objective is to convert the abrasion energy from the movement of the exhaust fume into useful energy.

Secondly, the law of conservation of momentum in equation 2 is considered for the resolution of the continuing ionized exhaust fume, in which (∂t ρu) and (ρuut) represents the momentum within the Magneto hydrodynamic system. The P in the equation 2 represents the external pressure of the exhaust fume leaving the Magneto hydrodynamic system.

Thirdly, the induction equation, equation 3 measures the magnetic induction energy transferred into the Magneto hydrodynamic system. Fourthly, the conservation of energy law, equation 4, similar representation of the conservation of mass, is used in the calculation of the energy tracked down by the Magneto hydrodynamic system.

Fifthly, the divergence law, equation 5 is used to compute the current trapped by the Magneto hydrodynamic as shown Fig. 3.1. The general representation of the flow of the exhaust fume (gas) in diagrammatic form is shown in Fig. 3.1.

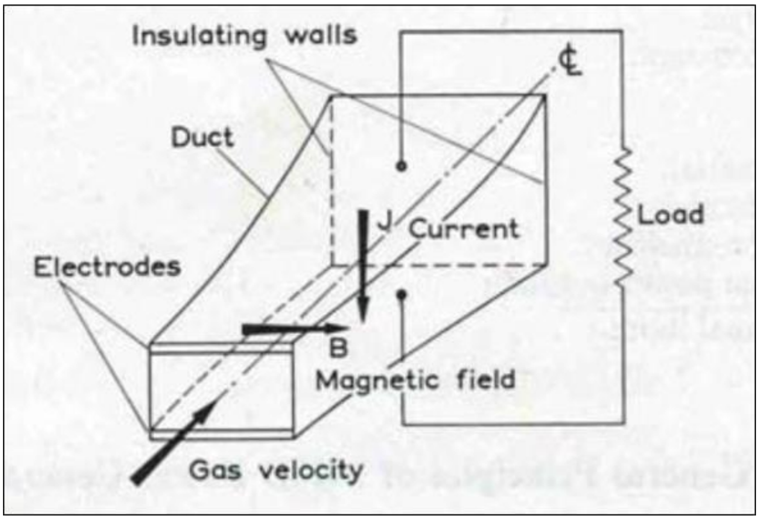

Figure 1 Schematic arrangement of an MHD duct

The compressible flow of an electrically-conducting fluid is described for the inviscid case by the equations 1 to 5 (Tillack etal., 1998).

$$t\rho + \rho u = 0 \text{ (Conservation of Mass) ……………… (1)}$$

$$\partial t\, \rho u + \rho uut + P = 0 \text{ (Conservation of Momentum) ………………(2)}$$

$$\partial t\, B + uBt + But = 0 \text{ (Induction Equations) ……………….. (3)}$$

$$\partial t\, \rho e + \rho eu + Pu = 0 \text{ (Conservation of Energy) ………………. (4)}$$

$$\nabla \cdot B = 0 \text{.(Divergence Constraint)…………..(5)}$$

Where, u is the velocity, ρ is the density, P is the pressure, B is the magnetic field, and e is the total energy.

The basic electrical characteristics of MHD generators are power output of W, which is shown in Eqn. 3.6, and is generated in the working fluid volume. The local electrical efficiency η, as shown in Eqn. 3.7 is equal to the Electrical output density.

$$W = \int J.E.dV \ldots\ldots\ldots\ldots(6)$$

$$\eta = \rho \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The Electromagnetic body force power density F, represented in equation 8 is a fundamental equation in the calculation of the force on the walls of the constructed Magneto hydrodynamic system. This equation 8 is known as the Lorentz Force Law, the charge of the particle Q, is computed from the YX -36TRN Multi-tester meter measurements. The velocity of particle V, is computed from the SOX3 gas meter measurements, while the magnetic field B, is given in the properties of the magnet used, appendix 4.

$$F = QVB \text{ (Tillack etal., 1998) } \ldots\ldots\ldots\ldots\ldots (8)$$

From the above force equations it is observed that the performance of the MHD systems is dependent on the

- Length of the channel,
- The ionization of the fluid,
- Strength of the magnetic field, and
- Velocity of the fluid flow

3.2. pH and Acidity Level

The pH values of the input and output of the Magneto Hydrodynamic system was measured with a pH meter. Suppose you are given two unlabeled solutions: a 10−4M solution of KOH whose pH is 11, and a solution made by acidifying a .01M solution of Na2CO3 until its pH is 11. How would you tell which is which? One way would be to titrate each solution with a strong acid such as hydrochloric acid (HCl); you would compare the amount of HCl required to bring the pH of each solution to some arbitrary reference value, not necessarily 7 (neutral).The free acidity level which was measured with a pH meter and the potential radical formulation computed is a measure of the Detective proton concentration. The pH expresses only the intensity aspect of acidity; as such, pH is not conserved when the temperature, density, or ionic strength of a solution is changed, or when the concentration is altered (Lower, 2015).

4. Results and Discussion

The average of three sets of readings of the exhaust fume when there was no attachment of the constructed Magneto Hydrodynamic (MHD) system to the 800Watts generator used for test run, using the fieldpiece combustion check with auto pump model SOX3 meter is shown in Table 2, Likewise the average of three sets of readings of the exhaust fume with the attachment of the constructed Magneto Hydrodynamic (MHD) system to the 800Watts generator used for test run using the fieldpiece combustion check with auto pump model SOX3 meter is shown in Table 3.

In the Tables 2 and 3 temp represents temperature of the fume in ^{o}C, EA represents excess air in percent, Eff. represents the efficiency of combustion in percent. Note that all the readings were stated as it was exactly read out from the fieldpiece combustion check with auto pump model SOX3 meter of which an example was done in the presence of the Supervisor as shown in the pictorial diagram of figure 6.

Table 2 Measurements without Magneto Hydrodynamic system

Reading (minutes)	Oxygen (%)	Temp (°C)	CO_2 (%)	EA (%)	Eff. (%)
0.5	9.7	239.2	6.3	77	83
1	9.4	247.8	6.5	72	83
2	8.8	262.2	6.8	64	83
3	8.8	266.1	6.8	64	83
4	7.9	267.5	6.8	66	83
5	8.9	267.5	6.8	66	83
10	8.8	268.1	6.8	64	83
15	8.8	269.1	6.8	64	83
20	8.7	269.3	6.9	63	83
25	8.8	269.3	6.8	64	82
30	8.8	267.4	6.8	64	83
35	8.8	267.4	6.8	64	83
40	8.7	267.3	6.9	63	83
45	8.8	265.9	6.8	64	83
50	8.7	268.1	6.9	63	83
55	8.7	268.8	6.9	63	83
60	8.8	266.0	6.8	64	83

Table 3 Measurements With Magneto Hydrodynamic system

Reading (minutes)	Oxygen (%)	Temp (°C)	CO_2 (%)	EA (%)	Eff. (%)
0.5	22.9	97.4	0	0	85
1	22.8	97.6	0	0	86
2	22.8	98.8	0	0	85
3	22.9	101.2	0	0	86
4	22.9	102.5	0	0	88
5	22.9	103.3	0	0	87
10	22.2	108.2	0	0	88
15	22.1	110.7	0	0	88
20	20.3	113.8	0	0	85
25	20.6	114.6	0	0	85
30	21.5	116.5	0	0	85
35	22.5	116.4	0	0	86
40	22.7	118.0	0	0	88
45	22.8	116.8	0	0	87

50	23.0	114.9	0	0	88
55	23.1	114.4	0	0	88
60	23.1	114.6	0	0	89

But % $C0_2$ Max is a calculated maximum value for the $C0_2$ produced from petrol during combination and this value is 16%

$$\therefore \%\ C0_2 + \%C0 = \%C0_2 \text{ Max } (11)\ a$$

Hence $\%C0 = \%C02 \text{ Max} - \%C02$ (11) b

From equation (9)

100 - % $C0_2$ - %C0 - %0_2 = %N_2 (11) a

Or

% N_2 = 100 - %$C0_2$ - % 0_2 (4.4) b

Table 4 Average Moisture content Result

Without MHD system	With MHD system
0.25ml	0.60ml

Table 5 Average Electrical Conductivity Result

Without MHD system	With MHD system
Voltage Nil	-20-Volts Instantaneous Voltage
Resistance Nil	Constant 5kΩ

Table 6 Average Sooth Content Result

Without MHD system	With MHD system
0.340grams	0.250grams

Table 7 Average pH value Result

Without MHD system	With MHD system
5.0	8.0

4.1. General analysis of the constructed system

The average moisture content was measured as already mentioned in chapter 3 by reading out the volume of water remaining in the hose of the SOX3 Fieldpiece combustion check meter which was poured into a 5-ml measuring tube, and the result got is shown in Table 4. This result showed that there was a tripled volume increase in water produced when the MHD system was applied, and hence shows that a more friendly output of the combustion arose. Also as already mentioned in chapter 3 the sooth content of the exhaust fume for both when the MHD system was not applied and when it was applied by measuring the weight of a wet filter paper before and after its exposure to the exhaust fumes. The result of these sooth content are shown in Table 6 and shows that the efficiency of combustion was reduced from 0.34grams to 0.25grams which further proves the result in Table 2.

It was observed from Table 4.6 that the ph value for the exhaust fume before the application of the MHD system is 5.0, which showed an acidic exhaust fume. But when the MHD system was applied the pH was given as 8.0, which showed a basic exhaust fume. These of course further prove the equation 4.5 which shows the conversion of KOH (acidic) into K_2CO_3 (basic). Since a basic environment is proven to be a healthier environment this showed an improvement to an environmentally safe exhaust fume.

For the analysis of the Normal plots of percentage Oxygen output for both the MHD system attached and that without the MHD system to time as seen in Fig. 4.1, shows that there was a marked increase in the Oxygen production when the MHD was attached. In the plot of Carbon (iv) Oxide for both the attached and not attached MHD system, as seen in Fig. 4.3 shows only values of Carbon (iv) Oxide in test run without the MHD system, while the one with the MHD system attached showed values of zero. This is because the salt, Potassium hydroxide used up all the Carbon (iv) oxide (CO_2) produced as was earlier mentioned in ch.apter 4.2.

For the Normal plots of Efficiency in Fig 6, there was an increase from 83% to 87% on the average, this shows that the combustion efficiency of the Generator was increased by this margin. The Normal plots for exhaust temperature Fig. 3 showed a reduction of the exhaust temperature from 264.53^o C to 109.53^o C on the average. While the Excess-air plot for both system shown in Fig. 5 had only values for the non-attachment of the MHD system. This is because the catalyst (Potassium hydroxide) used, reacted with all Carbon (iv) oxide and therefore prevented the need for excess air in the conversion of Carbon (iv) oxide from Carbon (ii) oxide.

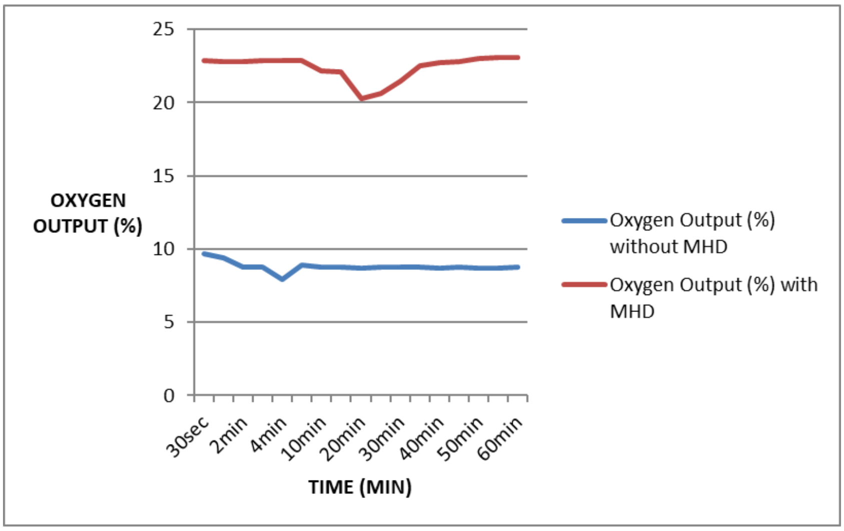

Figure 2 Plot of oxygen Output verse time

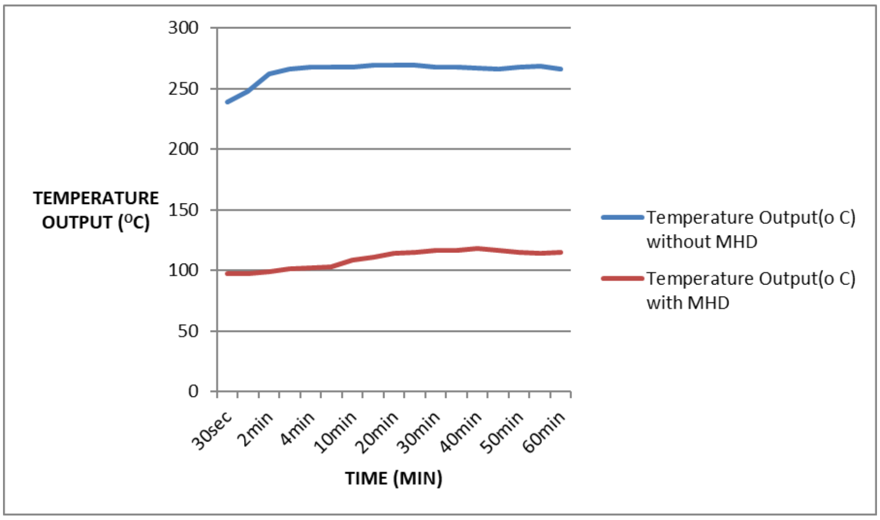

Figure 3 Plot of Temperature Output verse time

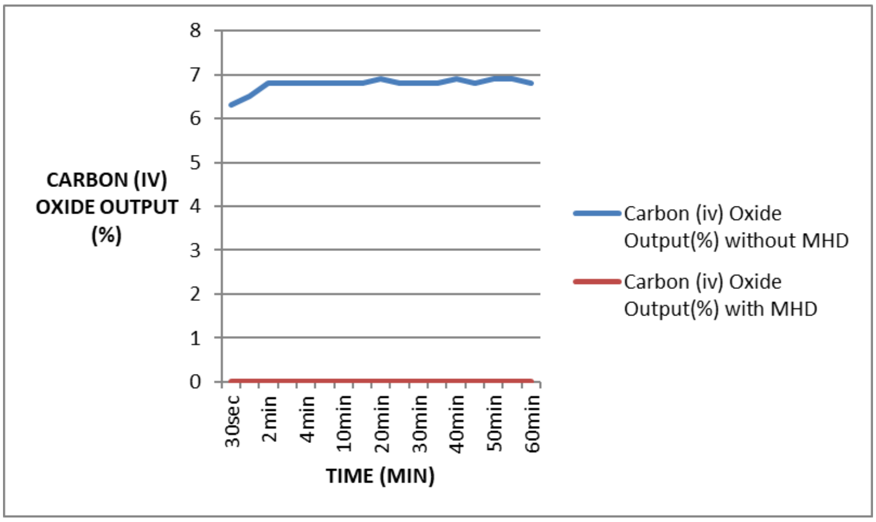

Figure 4 Plot of carbon (iv) Oxide Output verse time

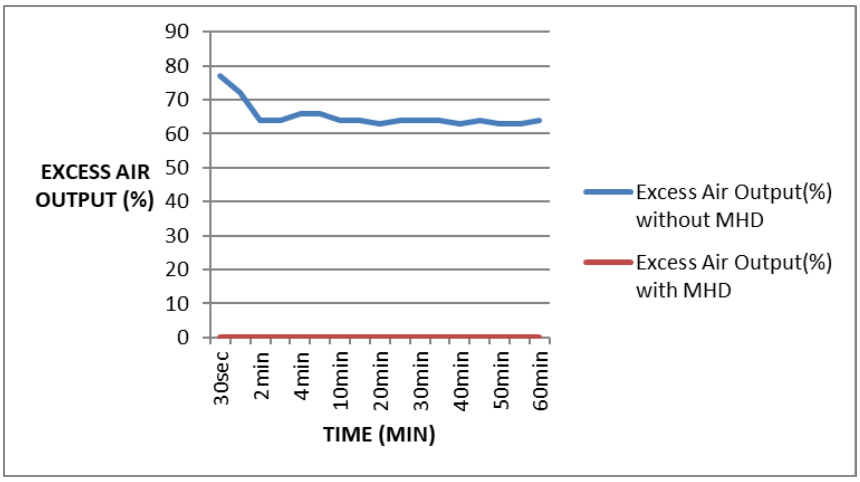

Figure 5 Plot of Excess Air Output verse time

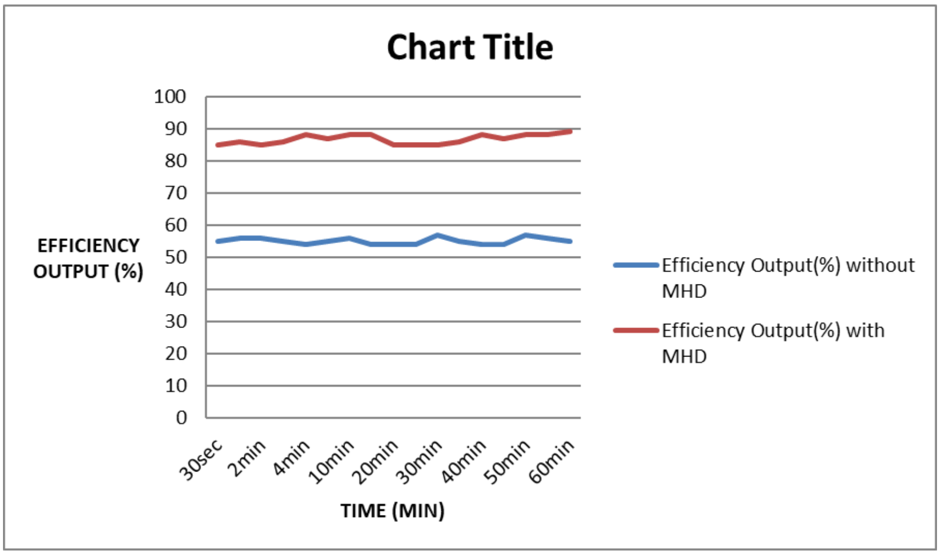

Figure 6 Plot of Efficiency Output verse time

References

[1] AR4 SYR (2007), "Three different approaches are used to describe uncertainties each with a distinct form of language", Intergovernmental Panel on Climate Change (IPCC), Synthesis Report, Treatment of Uncertainty, New York, USA. Pg. 360.

[2] Asplund, R.W., (2008).”Profiting from Clean Energy; A complete guide to Trading Green in Solar, Wind, Ethanol, Fuel cell, Power Efficiency, Carbon Credit Industries and more. 1st Ed.”, John Wiley and Sons Inc., New York. Pg. 20.

[3] Blue, Jessica, (2013). "What is the Natural Greenhouse Effect?". National Geographic (magazine). Retrieved 27 May 2013. 560 – 564.

[4] IPCC AR5 WG1 2013a "Warming of the climate system is unequivocal", Intergovernmental Panel on Climate Change (IPCC), Climate Change 2013: The Physical Science Basis - Summary for Policymakers, Observed Changes in the Climate System, New York, USA Pg.2..

[5] IPCC AR5 WG1 2013b "Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010It ", IPCC, Climate Change 2013:.New York, USA. Pg. 6.

[6] Lower S. K. (2015), “Acid-base Equilibria and Calculations”, A Chem1 Reference Text, Simon Fraser University, Canada. Pg. 1.

[7] Riebeek, H. (2010). "Global Warming: Feature Articles". Earth Observatory, NASA Goddard Space Flight Center.’ New York, Usa. Pg. 53.

[8] Tillack M. S. and Morley N. B. (1998),“Magnetohydrodynamics, 14th Edition”, Standard Handbook for Electrical Engineers, McGraw Hill. USA. Pg. 1.