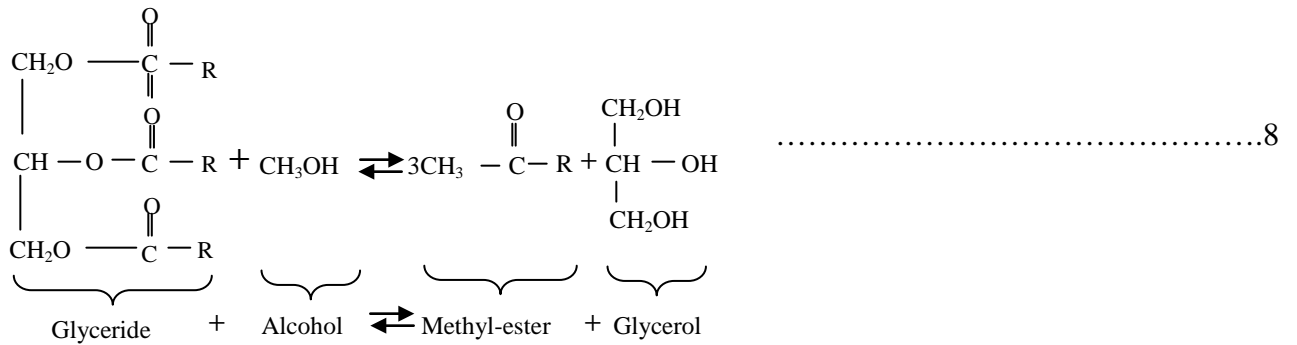


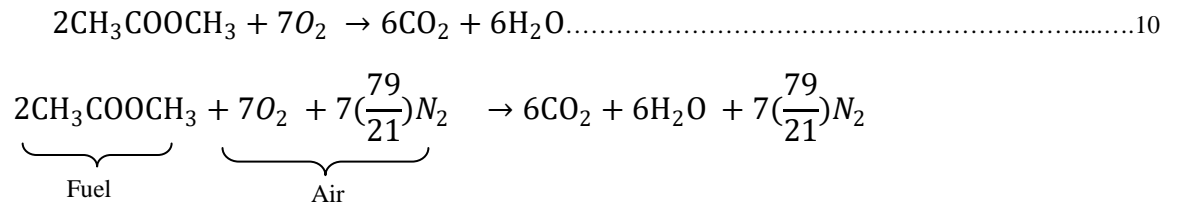
Figure 5: Selection of Fuel Injector

Meanwhile, position for the fuel injector is specified on the CC and the biodiesel fuel used is analyzed. The chemical formation of the biofuel (methyl-ester) is a product of glyceride and alcohol as shown in the reversible and structural equations as presented in equations 8 and 9 respectively.

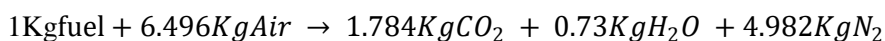
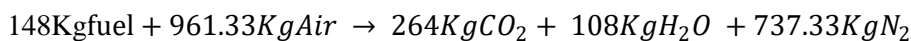
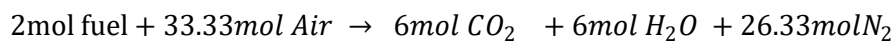


where R is a methyl radical.

Meanwhile, the condensed formula of the methyl-ester (methyl-acetate) can be written as:-  $\text{CH}_3\text{COOCH}_3$  or  $\text{C}_3\text{H}_6\text{O}_2$  which is used for the stoichiometric chemical combustion equation as presented in equation 10.



The mole and mass ratio of fuel and air reaction in the equation above for 100% theoretical air is given as:-



This yields 7.496kg of the reactants giving the same value of the products, confirming the law of conservation of matter. Subsequent results from the gravimetric and volumetric analysis of the combustion process of this study is presented in figures 6 – 8 graphically.

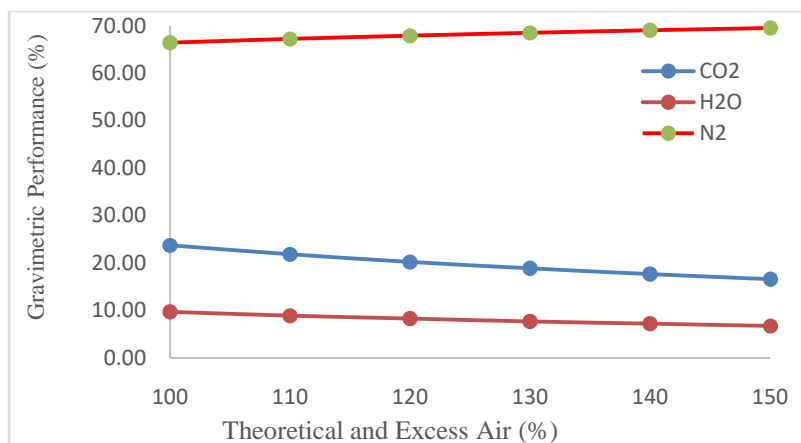


Figure 6: Gravimetric Analysis Result

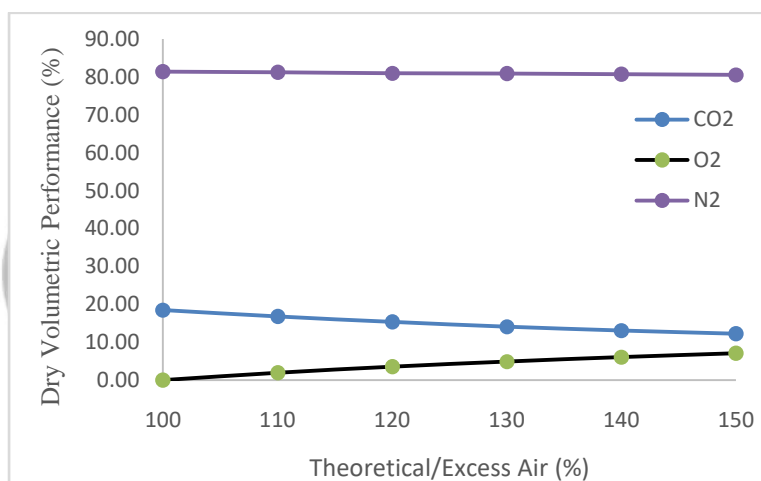


Figure 7: Dry Volumetric Result Analysis

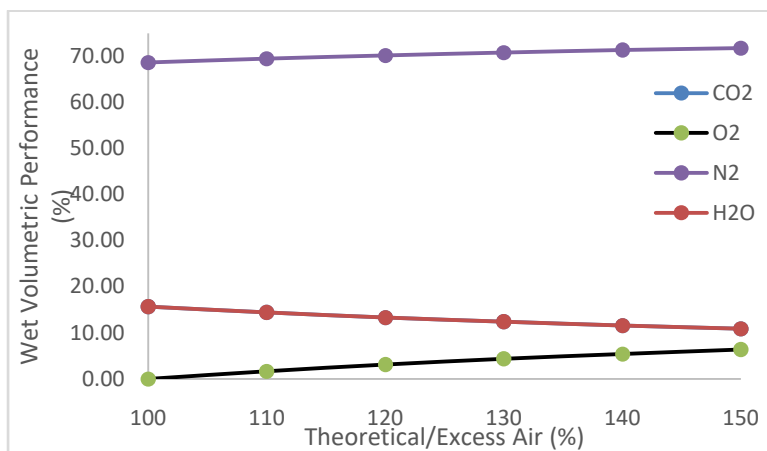


Figure 8: Wet Volumetric Result Analysis

The graphical results are presentation of the products of the stoichiometric combustion equations which by all indication are complete combustion process. It is obvious that complete combustion process always gives off CO<sub>2</sub> and H<sub>2</sub>O as products of the reaction of fuel and air. Thus, the results from this study confirms this fact. However, the results shows reduction of CO<sub>2</sub> production from (23.8 – 16.61)%, (18.56 – 12.25)% and (15.56 – 10.91)% in figures 6, 7 and 8 respec-

tively as excess air is supplied to the combustion process. Meanwhile, the analytical values of CO<sub>2</sub> and H<sub>2</sub>O for figure 8 are almost the same hence, the plots in the graph appears as one entity. Similarly, the exhaust water from the engine at the end of the combustion also decreases in percentage from (9.74 – 6.79)% and (15.56 – 10.91)% in terms of gravimetric and wet volumetric analyses. Contrarily, the formation of air with its two key components (oxygen and nitrogen) at the end of the combustion process improves in their percentage performance. The combustion of biodiesel with theoretical air of (100 – 150)% gives an increment of O<sub>2</sub> and N<sub>2</sub> from (0 – 7.05)% and (66.45 - 69.55)% gravimetrically and it is shown in figure 6. Likewise, these components of air in the wet volumetric analysis as shown in figure 8 increases from (0 – 6.36)% and (68.70 – 71.82)% for O<sub>2</sub> and N<sub>2</sub> respectively. These results attests that the use of biodiesel in replacement of fossil fuel will not in any form cause degradation and poisonous emission to the environment.

## IV CONCLUSION

The study of optimizing the CC of a diesel engine for power generation in order to produce little or no emission can be concluded with the following conclusive points.

- Analysis from the study affirms that biodiesel can serve as alternative fuel in diesel power generating plant after the optimization of the CC.
- The chemical combustion of biodiesel such as methyl-acetate with air in the CC of diesel engine produces harmless products to the environment.
- The process of generating biodiesel is safe, more economical compared to its rival, environmentally friendly and readily available everywhere since its raw materials is mostly agricultural crops.

Therefore, carrying out design optimization for the CC of a diesel engine to generate electric power is one means of putting off fossil fuelled plants. Hence, the continuous embracing of the alternative sources and keeping the environment free from any form of emissive pollutant(s) should be the target of above research.

## REFERENCES

- [1] M. Kampa and E. Castanas, "Human Health Effects of Air Pollution: 4th International Workshop on Bio-monitoring of Atmospheric Pollution". *Environmental Pollution-Elsevier*, Vol.151, No.2, pp. 362-367, 2008.
- [2] W.L. Hardy and R.D Reitz, "A Study of the Effects of High EGR, High Equivalence Ratio, and Mixing Time on Emissions Levels in a Heavy-Duty Diesel Engine for PCCI Combustion" *SAE Technical Paper*, 2006-01-0026, 2006.
- [3] E.A.M Fogleman, "Application of the proper orthogonal decomposition to datasets of internal combustion engine flows". *Journal of Turbulence* Vol.5, pp.1-23, 2004.
- [4] K. Ugur, "Study on the design of inlet and exhaust system of a stationary internal combustion engine". *Elsevier-Energy Conversion and Management*, Vol. 46, No.13-14, pp.2258–2287, 2005.
- [5] G. Stefan, "CFD modeling of a four stroke S. I. engine for motorcycle application". Unpublished MSc. Thesis, KTH Industrial Engineering and Management, Stockholm, Sweden, 2009
- [6] Y. Sun, T. Wang, Z. Lu, and L. Cui, "The Optimization of Intake Port using Genetic Algorithm and Artificial Neural Network for Gasoline Engines". *SAE Technical Paper* 2015-01-1353, 2015.
- [7] S.W. Park, "Optimization of Combustion Chamber Geometry for Stoichiometric Diesel Combustion Using a Micro Genetic Algorithm". *Elsevier-Fuel Processing Technology*, Vol.91, No.11, pp. 1742-1752, 2010.
- [8] P. Senecal and R. Reitz, "Simultaneous Reduction of Engine Emissions and Fuel Consumption Using Genetic Algorithms and Multi-Dimensional Spray and Combustion Modeling". *SAE Technical Paper* 2000-01-1890, 2000.
- [9] J. Lim and K. Min, "The effects of spray angle and piston bowl shape on diesel engine soot emissions using 3-D CFD simulation". *SAE Technical Paper* 2005-01-2117, 2005.
- [10] J. Song, C. Yao, Y. Liu, and Z. Jiang, "Investigation on flow field in simplified piston bowls for DI diesel engine". *Eng. Appl. Comp. Fluid* 2(3), 354–365, 2008.
- [11] Perkins, "Perkins 403D-15G Diesel Engine" [Online] Available: <https://www.perkins.com> > Perkins > Electric Power Generation > Diesel. Accessed 27<sup>th</sup> December, 2019