



# Design and Simulation of the Operating Parameter of an Updraft Gasifier for Onyeama Coal

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## Abstract

The design and MATLAB simulation of the operating parameter of onyeama coal in an updraft gasifier was investigated. The operating parameters considered are: power rating, air required, fuel consumption, hopper volume, time, reactor diameter and height. These results show that there exist linear relationship of all the operating parameter with the power rating. It can be deduced that the sizing of the updraft (diameter and height) increased commensurately to increase in the power rating requirement and the operational time respectively. The lower values of the power rating obtained for the reactors diameter is a function of the coals heating value as well as the power rating requirement. The power rating should not be more than 700KW to obtain the optimal fuel consumption requirement. It can be established that onyeama coal proved to be more conservative in terms of the amount of coal that would be required for a particular rating.

**Keywords:** operating parameter, MATLAB, Onyeama coal, simulation

## 1. INTRODUCTION

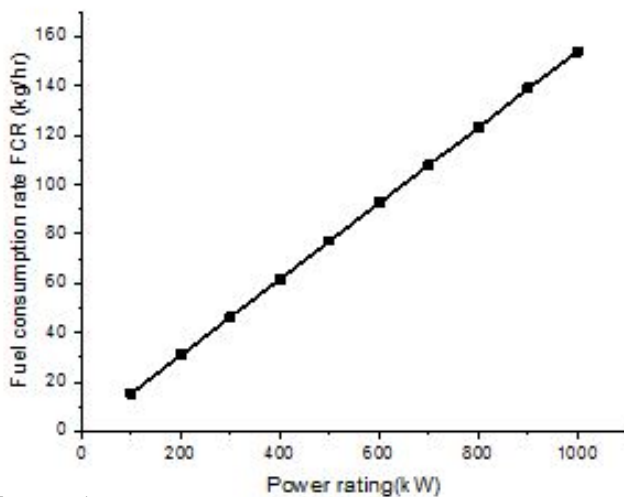


Figure 1: Variation of Fuel consumption rate and power required.

Energy and good healthy condition has been reported to be the most significant aspect of life necessary for the societies [1]. The global need of energy sources such as crude oil, coal and natural gas with 33.28%, 28.11% and 24.13% in ranking has been reported in 2016 as the highest energy sources consumed globally [2, 3]. Among the three sources of energy, coal is the cheapest and least expensive as compared with crude oil and natural gas that are depleting [2]. It is clear

that research into coal as a fuel is not only timely but important at this period in the world energy sources [2, 4]. However the use of coal as an energy source is always accompanied with higher emission of carbon monoxide and carbon dioxide [1]. The design of gasifier is one of the greater factors in the development of a gasifier for the gasification of coal for power generation. The design of any gasifier is usually accomplished with many assumptions in operating parameter, kinetic and thermodynamic effect that affect the gasification of the coal [4]. These factors vary from one coal source to another. Another factor mentioned is the operating parameter and has been reported as the most significant factor that affects the successful operation of coal gasification [5]. In this present work, the design and simulation of the operating parameter of an updraft gasifier for Onyeama coal is studied.

Table 1: Composition of Onyeama coal.

Proximate analysis		Ultimate analysis	
Moisture %	5.87	H%	3.8
Volatile matter	29.61	C%	86.55
Fixed carbon	63.61	N%	1.2
Ash	1.25	S%	0.6
Calorific value	33.33	ASH	1.25

Source: [3]

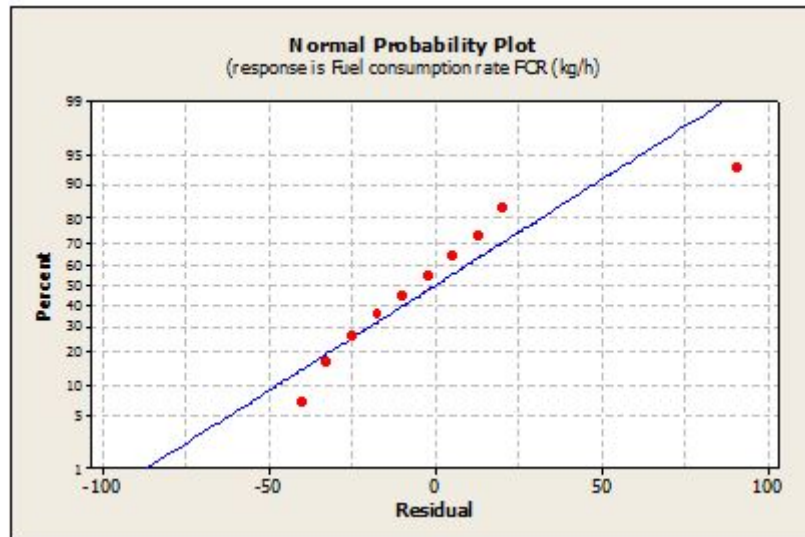


Figure 2: Residual plots for the fuel consumption and power rating.

## 2. MATERIALS AND METHOD

The updraft coal gasifier was designed using relevant design equations and criteria. MATLAB software was used in determining the operating parameter using Onyeama coal with composition displayed in Table 1. The model equations were adopted from the work of Hong et al. [6].

The core essence of the simulation was to see the trend in the design sizing of the system if the power requirements, reaction times as well as the inherent coal were not constant. Hence the simulation graphs will give an outline for knowing what the system sizing will be if any parameter is selected within the range of the three design factors as (i.e. power requirements, reaction times as well as the inherent coals).

## 3. FINDINGS AND ARGUMENTS

### 3.1. Power rating and fuel consumption rate

Figure 1 displayed the plot of fuel consumption and power rating requirement for the updraft gasifier. As the power rating increases from 100kW to 1000kW, the fuel consumption rate also rises. Due to its high heating value, the coal has low economic fuel consumption close to that of the calculated fuel consumption of 108.6kg/hr. Equation (1) is the linear regression equation and the percent/residual curve displayed in Fig. 2.

$$\text{Fuel consumption rate FCR (kg/h)} = 0.080 + 0.154 \text{Power required (kW)} \quad (1)$$

From Eq. (1), a linear relationship exists between fuel consumption with the power required for the gasification with a constant coefficient of 0.080. Inputting this in Eq. (1), the coefficient of power requirement for the gasification is 0.154. The Pred R-Squared has a value of 100%. While the Adj R-Squared also has a value of 100% and 0.168280 as standard deviation. Thus the model is significant.

Figure 2 presents the residual plot for the analysis. Figure 2 showed the experimental value is close

to the predicted values since the points are randomly distributed close to the line in the plot. It can be seen from the values of the Pred R-Squared and was close to 100.0% for the Adj R-Squared. This work has shown that for optimal gasifier performance, the power rating is 700kW since the value of fuel consumption at 700kW power rating is 108Kg/hr, which is close to that of the calculated values 108.6Kg/hr.

## 4. CONCLUSION

The design and MATLAB simulation of the operating parameter of Onyeama coal in updraft gasifier was investigated. The design operating parameters considered in the work are: power rating, air required, fuel consumption, hopper volume, time, reactor diameter and heights. These results show that there exist linear relationship of all the operating parameter with the power rating. It can be deduced that the sizing of the updraft gasifier (diameter and height) increased commensurately to increase in the power rating requirement and the operational time respectively.

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