Thermal efficiency improvement of Biomass for electricity generation by using Information Technology and Numerical methods

RANIPET HAFEEZ BASHA, SHUICHI TORII
Graduate School of Science and Technology, Kumamoto University, 2-39-1 Kurokami, Kumamoto, Japan
Email: hafeezbasha@gmail.com

Abstract: Thermal energy based power generation is significant in most of the countries, but due to the depletion of fossil fuels there is a serious threat to its fuel supplies. Biomass has proved to be alternative fuel to coal with benefits of being renewable and sustainable source of energy. But the efficiency of such plants is significantly low because of lower thermal performance of biomass. Producing advanced material, increasing its calorie and reducing carbon emissions are the objectives of this research. Pre-treatment methods based on chemical, bio-chemical and thermo-chemical process can increase the performance of the fuel, but it requires initial supply of energy. The use of information technology and numerical methods in developing the renewable fuel by achieving the above objectives is the novelty of this study. Biomass is combination of multiple waste materials where alteration in its ratio can change its heat of combustion. The user interface based computer simulator with enhanced feature of predicting optimum composition of Biomass was developed in our laboratory using J2SE 5.0 program. Refuse Derived Fuel type biomass sample was simulated to get numerical results which were tested and validated with physical experiment where the values were equivalent. Combinatory optimization methods along with probability and permutations & combinations were used in the design of this software. Artificial Neural Networks and Genetic Algorithms based methods can be applied to reduce the computational time and increase the efficiency of simulator. Hence the use of information technology and numerical methods along with pre-processing methods of biomass together would improve the thermal efficiency of Biomass power plant to generate clean electricity.

Keywords: Biomass, Combustion, Database, Computer Model, Numerical Simulation, Predictor

1. Introduction:

1.1. Background:
Most of the countries are dependent on thermal energy as a source of power generation, but due to the depletion of fossil fuels there is a serious threat to the fuel supplies. Biomass energy is not only a green technology, but also a renewable energy source that can replace coal quickly and cost-effectively, providing the same operational benefits while dramatically improving the environmental profile of energy generation. Biomass is available naturally in various forms depending on the human activity and accessibility to resources at particular locations. This environment friendly biomass has wide applications not only in producing renewable energy but also in industrial kilns, domestic cooking, construction material, etc.

1.2. Problem Description:
Efficiency of biomass plants is significantly low when compared to coal based thermal power stations because of lower thermal performance of biomass. In purpose of improving the efficiency effectively, biomass needed to be treated or pre-treated before using it in energy system or transform into other energy phase. Pre-treatment methods based on chemical, bio-chemical and thermo-chemical process can increase the performance of the fuel, but it requires a supply of initial energy. Moisture content of fuel in a thermal power plant plays a significant role in determining its efficiency, as the performance increases with decrease in moisture.

1.3. Hypothesis:
Biomass is not a single material, but it’s a mixture of different types of waste materials like Municipal Solid Waste, Agricultural Waste, Industrial Waste, etc. Choice of Biomass based on availability and its evaluation can give insight to optimum use of fuel. Altering the composition of Biomass shall yield different performance values in terms of thermal efficiency.

1.4. Significance and Objectives:
Use of Information Technology and Numerical Methods in developing Renew-able Energy is the novelty of this project to achieve the following objectives:
1. Producing Advanced Material from Combustible Waste
2. Increasing Thermal Efficiency of Biomass Fuel
3. Reducing Global Warming and Pollution
2. Materials and Method:

![Model of Biomass Plant in Hyderabad City (India)](image)

Figure 1: Model of Biomass Plant in Hyderabad City (India)

2.1. Refused Derived Fuel (RDF):
It is produced from combustible components of municipal solid waste (MSW) using mechanical heat treatment and waste autoclaves where the MSW is shredded, dried naturally under the sun, separation of non-combustible components like glass, metals and sand, size reduction and subsequent pelletization.

![Samples of Biomass Pellets collected from Ho Chi Minh City (Vietnam)](image)

(a) Waste Wood Pellet  
(b) Rice Husk Small  
(c) Rice Husk Big

Figure 2: Samples of Biomass Pellets collected from Ho Chi Minh City (Vietnam)

2.2. Classification of Biomass:
In this study different types of Biomass were identified and organized based on its role in combustion. It was classified into 8 types and 27 sub-types depending on its source and species.

2.3. Proximate and Ultimate Analysis:
Proximate Analysis determines the physical properties of Biomass in terms of moisture content, volatile matter, fixed carbon and ash. Ultimate Analysis determines the chemical properties of Biomass like presence of carbon, hydrogen, oxygen, nitrogen and sulphur. Proximate and Ultimate analysis was performed on the classified biomass types and its values were stored in the computer database.

2.4. Database Management:
The computer database manages the data related to identification of Biomass resources by using geospatial Software / Geographical Information System (GIS) which is location based data, Evaluation of fuel by using a Biomass Town Simulator based on availability, and performance improvement using Biomass combustion simulation and prediction software based on thermal efficiency.

2.5. Software Development:
Geospatial Software was developed at National Renewable Energy Laboratory (NREL), USA http://www.nrel.gov/biomass/ Biomass Town Simulator was developed at Institute of Industrial Science, the University of Tokyo where as the Biomass Combustion Simulation and Prediction Software was developed at Thermal Engineering Laboratory, Kumamoto University, Japan.

2.6. Validation:
Biomass Combustion Simulation and Prediction Software need validation in order to improve its performance. Samples of Refuse Derived Fuel were collected from Hyderabad City (India), Ho Chi Minh City (Vietnam) and Kumamoto City (Japan). Comparison study and analysis was done on Numerical Simulation and Experimental values.
Thermal efficiency improvement of Biomass for electricity generation by using Information Technology and Numerical methods

3. Results:
Refuse Derived Fuel (RDF) type biomass pellets collected from Ho Chi Minh City University of Technology were used for experimentation. The heat of combustion for the samples was determined by using a bomb calorimeter. Numerical simulation was also performed using the proposed Biomass Combustion Simulator & Predictor on same samples and values were obtained.

Figure 3: Biomass Simulator and Predictor Software

Figure 4: Source Code of Biomass Simulator Software in J2SE

Figure 5: Graph showing the comparison of Experimental and Numerical Results
The below table shows the results of both experimental and numerical simulation results:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Type</th>
<th>Weight</th>
<th>Heat of Combustion</th>
<th>Heat of Combustion</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Wood Pellet</td>
<td>0.6814 gm</td>
<td>4034.58 Kcal/Kg</td>
<td>4645.55 Kcal/Kg</td>
</tr>
<tr>
<td>-</td>
<td>Rice Husk (S)</td>
<td>1.5202 gm</td>
<td>3748.21 Kcal/Kg</td>
<td>3905.13 Kcal/Kg</td>
</tr>
<tr>
<td>-</td>
<td>Rice Husk (B)</td>
<td>0.7787 gm</td>
<td>3755.85 Kcal/Kg</td>
<td>4035.30 Kcal/Kg</td>
</tr>
<tr>
<td>-</td>
<td>Rice Husk (B)</td>
<td>1.425 gm</td>
<td>3521.54 Kcal/Kg</td>
<td>3644.79 Kcal/Kg</td>
</tr>
<tr>
<td>-</td>
<td>Rice Husk (B)</td>
<td>0.7844 gm</td>
<td>3504.82 Kcal/Kg</td>
<td>3641.14 Kcal/Kg</td>
</tr>
</tbody>
</table>

**Conclusion:**
The experimental and numerical results were compared and analyzed and it was observed that the values of numerical results were slightly higher compared to experimental results but close enough to validate the developed computer model.

**References:**