

# A review of Bio Mass combustion and Mathematical modeling – State of art

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**Abstract:** This paper is a review of the importance of study of biomass and bio mass fuel. Also listed the steps of converting biomass in bio energy and bio fuel. This paper also gives the mathematical equations of conversions.

**Index Terms:** Bio mass, Combustion, Gasification, Pyrolysis, Mathematical, modeling, Momentum.

## 1 INTRODUCTION

Global warming is the alarming situation for all the nations on our planet. From the day when fossil fuel is started using, CO<sub>2</sub> level is continuously increasing. CO<sub>2</sub> is a green house gas as it absorbs the heat and holds it for more than a year. It results in rise in earth temperature which is very harmful for all living species.

There are different ways which can be followed to solve this issue:

- 1) Alternate for fossil fuel
- 2) Removal of CO<sub>2</sub> gas from atmosphere
- 3) CO<sub>2</sub> emission control from flue gas

Diesel, petrol, coal are the fossil fuels which are limited and takes million of years to form in the core of earth. Benefits of alternate fuels are as follows:

- 1) Which we can produce continuously
- 2) Which emits less or no CO<sub>2</sub>

Some examples of these fuels are

- 1) Solar energy
- 2) Wind energy.
- 3) Biomass Energy (Ethanol, Bio gas Methane)
- 4) Geothermal energy i.e. using energy from the earth.

Out of all these sources, biomass energy is promising and can be produced from easily available bio wastes. But to use it at large scale, lot of research is required. There are different types of biomass like wood and agricultural products, solid waste, landfill gas and biogas, and alcohol fuels (like Ethanol or Biodiesel).

Out of all these sources solid waste is easily available and cheap. If we use solid waste to produce energy then problem of dumping solid waste also can be solved.

## 2) BIOMASS

Biomass is fuel that is developed from organic materials, a renewable and sustainable source of energy used to create electricity or other forms of power.

We can either use biomass as a direct energy source or we can produce biomass like algae.

In biomass power plants either wood waste or other waste is burned to produce steam which runs a turbine to produce electricity, or that provides heat to industries and homes. Fortunately, new technologies including pollution controls and combustion engineering have advanced to the point that any emissions from burning biomass in industrial facilities are generally less than emissions produced when using fossil fuels like coal, natural gas, and oil. Biomass offers other significant environmental and consumer benefits, including improving forest health, protecting air quality, and offering the most dependable renewable energy source. And unlike other renewable power sources – such as solar and wind – a biomass power plant can operate 24/7, supplying a consistent and reliable and renewable stream of energy.

## 3) USE OF A BIOMASS AS ENERGY SOURCE:

Biomass can be converted into energy by one of the following process:

- 1) Combustion:
  - Co-Firing Process
  - Thermal Conversion
  - Gasification
  - Pyrolysis
  - Torrefaction
- 2) Chemical Conversion, Non-Combustion Processes

Since the biomass has a large amount of carbohydrates it can be converted into different chemicals which also can be used as fuels, like biomass oil, methane, alcohol etc.

There are three major methods to convert biomass in to fuel.

### 1) Combustion:

Biomass combustion refers to burning fuel in a boiler, furnace or stove to produce heat.

### 2) Gasification:

By gasification, the biomass is broken down in to combustible gas, volatiles and ash.

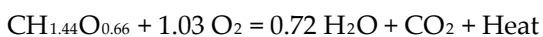
### 3) Pyrolysis:

In pyrolysis, biomass is heated in the absence of air. The process results liquid, solid and gaseous fractions, mainly gases, bio-oil and char.

### 4) COMBUSTION

Combustion is familiar to all of us, but many do not realize that it is essentially a chemical reaction. In the process of combustion, two ingredients (biomass and oxygen) are combined in a high temperature environment to form carbon dioxide, water vapour, and heat.

Biomass + Air → Carbon Dioxide + Water Vapours + Nitrogen + Heat



Note:  $\text{CH}_{1.44}\text{O}_{0.66}$  is the approximate chemical equation for the combustible portion of biomass.

### 5) MATHEMATICAL MODEL TO OPTIMISE THE PRODUCT AND ENERGY:

The mathematical model describing the combustion process is based on the equations of mass, momentum, species, and energy as well as equations for turbulence and models. The sub models for initial heat-up, drying, devolatilization, char combustion, and final heating/cooling of the ash include heat and mass transfer equations.

The generalized equations that govern the conservation of mass, momentum, and energy as well as the equations for

species transport can be written as:

the thermal decomposition of spherical wood particles of different sizes and varying properties by combining various processes such as heating, drying, pyrolysis, gasification, and combustion

The mathematical model is based on solving the partial differential equations of conservations of mass, momentum, and energy for a system containing a conventional cigarette and its surrounding air. The packed bed of cigarette rod with shredded tobacco particles is modelled as a porous media, which presents a resistance to the flow inside. The conservation equations on a macroscopic scale are derived by application of a volume averaging technique to the fundamental microscopic transport equations in a porous media. The air-cigarette boundary is a part of the solution to be determined; an ambient boundary condition is applied on the far field boundary where the effect of the presence of the cigarette is negligible, and thus, imposes no pre-conditioning on the final solution. All the gases behave according to the ideal gas law. In order to reduce complexity we have omitted thermal swelling and/or shrinkage as the solid fuel undergoes pyrolysis and oxidation, and also have not considered volatile species condensation in this model.

The different steps of combustion are given as follows:

#### a) Continuity equation

$$\frac{\partial(\phi \rho_g)}{\partial t} + \vec{\nabla} \cdot (\rho_g \vec{v}) = source_{mass}$$

Where SOURCE mass is equal to the net mass produced per unit volume per unit time due to moisture evaporation, tobacco pyrolysis and char oxidation.

#### b) Momentum equation

The general form of momentum equations for incompressible flow in a porous medium is given as

$$\frac{\partial(\rho_g \vec{V})}{\partial t} + (\vec{V} \cdot \vec{\nabla})(\rho_g \vec{V}) = -\vec{\nabla} P + \vec{V} \cdot (\mu \vec{\nabla}) \vec{V} + \rho_g \vec{g} - S$$

Where  $S = source_{mass}$

#### c) Gaseous species transport equations

Having the velocity flow field, the gaseous species concentrations are determined by solving the gas transport equation in a porous media for each species

$$\frac{\partial(\rho_g \phi Y_i)}{\partial t} + (\vec{V} \cdot \vec{\nabla})(\rho_g Y_i) = \vec{\nabla} \left[ \rho_g \phi (D_{gi} + D_m^d) \vec{\nabla} Y_i \right] + S$$

Where  $S = source_i$

#### d) Energy Equation

During the process of puffing, the time variation of the solid temperature is very rapid and the assumption of gas-solid thermal equilibrium is no longer valid. Therefore, a two-medium treatment is applied for the energy equation. The solid phase is treated as a continuum, and particle-scale gradients are excluded. The solid and gas phase energy equations are:

$$\frac{\partial((1-\phi)\rho_s C_{ps} T_s)}{\partial t} = \vec{\nabla} \cdot \left[ (K_{seff} + K_r) \vec{\nabla} T_s \right] + hA_v [T_g - T_s] + source_s$$

$$\frac{\partial(\phi \rho_g C_{pg} T_g)}{\partial t} + \vec{\nabla} \cdot \left( \rho \vec{V} C_{pg} T_g \right) = \vec{\nabla} \cdot \left[ (K_{seff} + \phi \rho_g C_{pg} D_t^d) \vec{\nabla} T_g \right] + hA_v [T_s - T_g]$$

To increase the range of application of the model it will be necessary to investigate the influence of flue gas recirculation below the grate, preheated combustion air and air staging below the grate. The work already performed provides a comprehensive basis for these investigations.

#### CONCLUSION

Through the simulation results, the conclusion can be drawn:

- 1) The oxygen is likely lack to burn the volatiles in the middle of furnace.
- 2) The combustion of the biomass is closer to the gas combustion because the fuel is about around 80% volatile, which is have a huge different from the coal.
- 3) The flame position in the furnace clearly down after the transformation, which improved the convective heat trans-

fer of the flue gas and the efficiency of the boiler.

- 4) A large space to ensure the stable and complete combustion of volatile gases after the transform the furnace structures are needed, but the transformation weakens the disturbance of the mixture.

#### REFERENCES

- 1) M.S. Saidi, M.R. Hajaligol, A. Mhaisekar, M. Subbiah, Elsevier, Applied Mathematical Modelling 31 (2007) 1970–1996
- 2) Tigabwa Y. Ahmed, Murni M. Ahmad, Suzana Yusup, Abrar Inayat, Zakir Khan, Renewable and Sustainable Energy Reviews 16 (2012) 2304–2315
- 3) Liang Yu, Pierre Christian Wensel, Jingwei Ma and Shulin Chen, Bioremediation & Biodegradation, Yu, et al. J Bioremed Biodeg 2013, S4  
<http://dx.doi.org/10.4172/2155-6199.S4-003>
- 4) Jingxia Sui, Xiang Xu, Bo Zhang, Changjiang Huang, Jinsheng Lv

A Mathematical Model of Biomass Briquette Fuel Combustion, Energy and Power Engineering, 2013, 5, 1-5

- 5) J. Porteiro \*, J.L. Míguez, E. Granada, J.C. Moran. Mathematical modelling of the combustion of a single wood particle, Fuel Processing Technology 87 (2006) 169 – 175
- 6) J Swithenbank, YB Yang, C Ryu, J Goodfellow, S Shaban-gu, N V Russell, F M Lewis\*, V N Sharifi  
*European Combustion Meeting (ECM2003) Plenary Lecture Biomass Combustion*
- 7) Xinhui Zhang University of Iowa, University of Iowa, Iowa Research Online Theses and Dissertations
- 8) M. Žecová, J. erpák,  
Mathematical modelling of gasification and combustion of biomass in matlab