

# Stages of Biomass gasification and chemical reactions

Ravindra Jilte

School of Mechanical Engineering, Lovely Professional University, Punjab

## Abstract

Gasification converts biomass into a combustible gaseous mixture by partial oxidation of biomass at temperatures of around 800-900°C in a gasification medium along with the small quantities of char and condensable and non-condensable gases. It converts the intrinsic chemical energy of the carbon in the biomass into combustible gas and is one of the efficient conversion ways to convert the energy present in the biomass. The present paper discusses on different stages of gasification. Chemical reactions occurring in different stages of gasification are also presented.

**keywords:** Biomass, Gasification, stages of gasification, chemical reactions

## 1 Introduction

Gasification converts biomass into the gas and solid phase. The gas phase is also known as the “syngas” which is utilized in the production of electricity and bio-oil. The leftover or residue produced during the gasification is a solid part which is known as “char”. The syngas chemically consists of CO, H<sub>2</sub>, CH<sub>4</sub> and CO<sub>2</sub>. Gases which are undesirable like H<sub>2</sub>S, HCl, N<sub>2</sub>, have also been found in the output gas. The LHV for syngas varies from the value of 4-13MJ/Nm<sup>3</sup>. [1]

## 2 Main stages of gasification

The basic processes involved in gasification are:

- 1 Oxidation
- 2 Drying
- 3 Pyrolysis
- 4 Reduction

The basic concepts involved in the production of gas from the biomass are shown in Fig.1

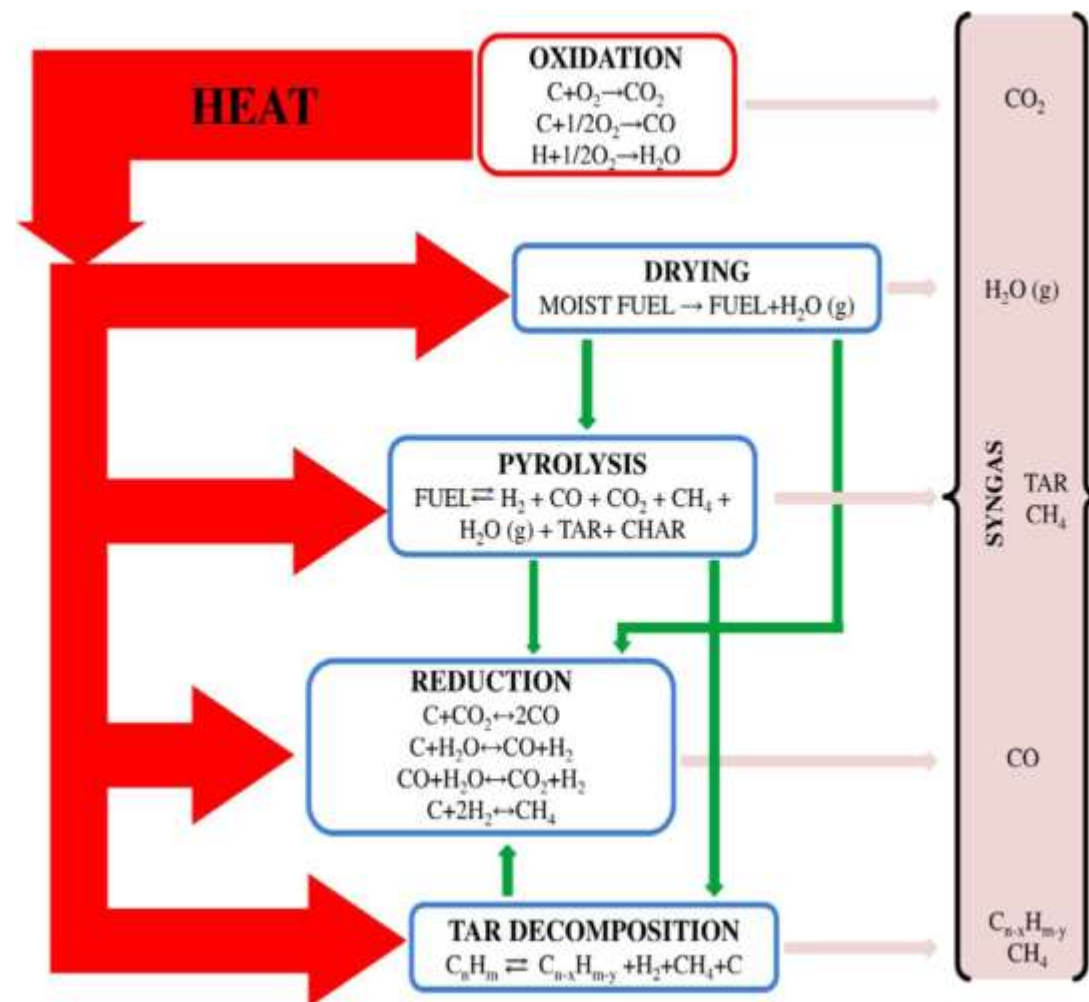
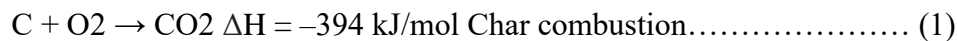


Figure 1 Block diagram of basic steps involved in gasification

### 3 Oxidation

There is a partial oxidation of biomass in order to release the heat from the oxidation reaction which is further utilized for drying and the pyrolysis process.

Basic reactions which occur in the oxidation phase are:



As shown in the above reaction the products obtained from combustion are mainly  $CO_2$  and  $CO$ .

Since the oxidation occurs with pure oxygen hence there is no presence of nitrogen in the combustion products. If the oxidation would have taken place in the presence of air nitrogen may

have been formed along with these products.

## 4 Drying

This is the first stage involved in the overall process of gasification where the moisture content of the biomass is reduced to the standard limits. Amount of heat consumption depends on the presence of moisture content in the feedstock. Drying is considered to be complete when biomass achieves temperature of about 150°C.

## 5 Pyrolysis

Pyrolysis involves the chemical breakdown of the large hydrocarbon molecules of biomass into smaller hydrocarbon molecules in the absence of air or oxygen at a specified rate to a maximum temperature, known as pyrolysis temperature and holding it there for a specified time. The decomposition of fairly complex cellulose molecule into smaller hydrocarbon molecules is shown in the figure 2. Pyrolysis breaks down the complex molecules to simpler molecules in the form of solid, liquid and gas. [2]

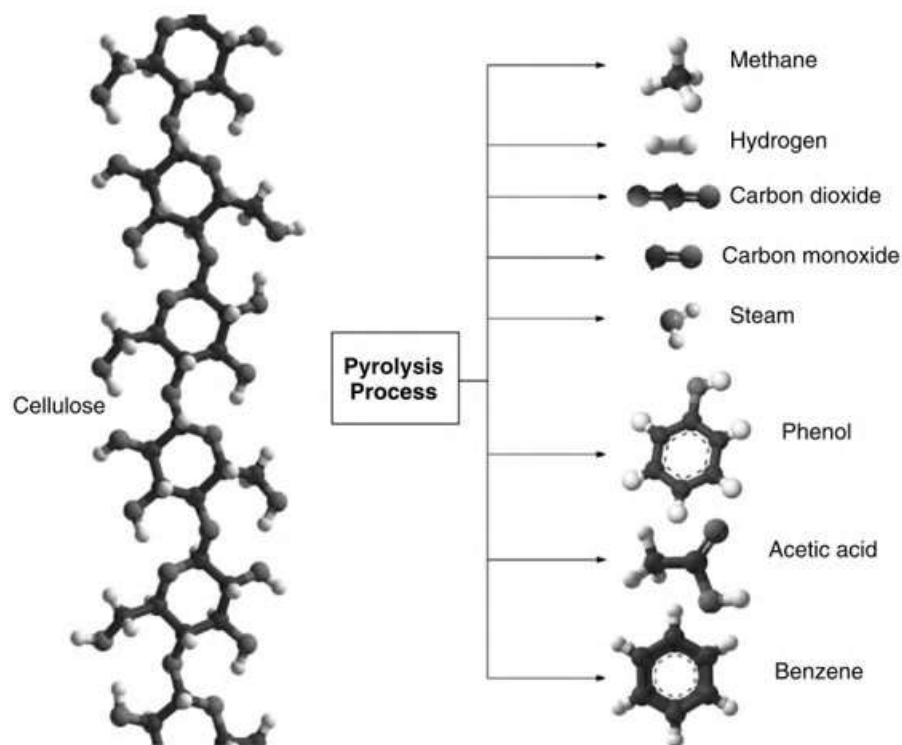


Figure 2 Degradation of hydrocarbon molecule during pyrolysis

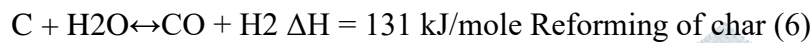
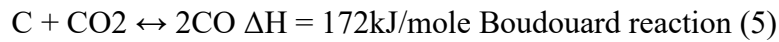
The solids consist mostly of char or carbon; liquid comprises of tar, heavier hydrocarbons and

water and the gas phase consists of condensable and non-condensable gases. The pyrolysis process may be represented by a generic reaction as:

The pyrolysis takes occurs in the temperature range of 250–700°C. The process is endothermic and the heat required comes from the oxidation step of the overall main processes occurring in the gasifier.

## 6 Reduction

The basic chemistry involved in the reduction are:



The chemical composition of syngas is greatly influenced by the temperature at which reduction takes place. At high temperatures the oxidation process of the solid residue increases. The temperature at which reduction takes place is an important factor for determining the characteristics of syngas and solid residue. The role of the reduction temperature is shown in the following figure 5.[3]

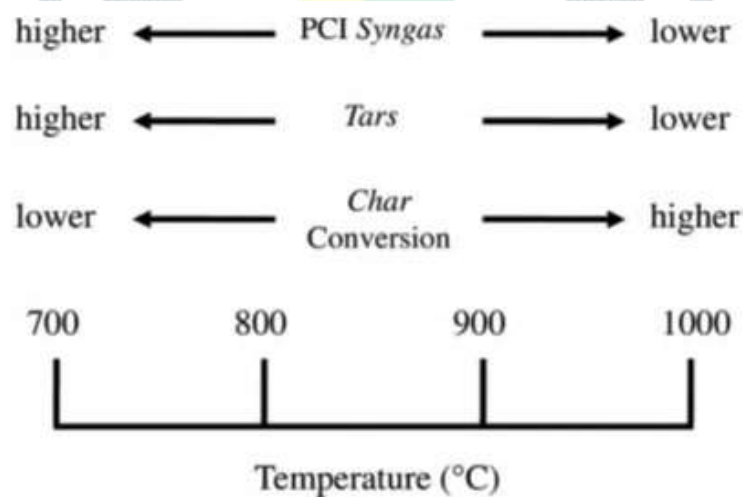


Figure 3 Influence of temperature on syn gas characteristics

## Conclusion

The efficient gasification of biomass depends on different stages of gasification. Chemical reactions occurring in different stages of gasification show the research areas corresponding to improve the conversion of biomass.

## References

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