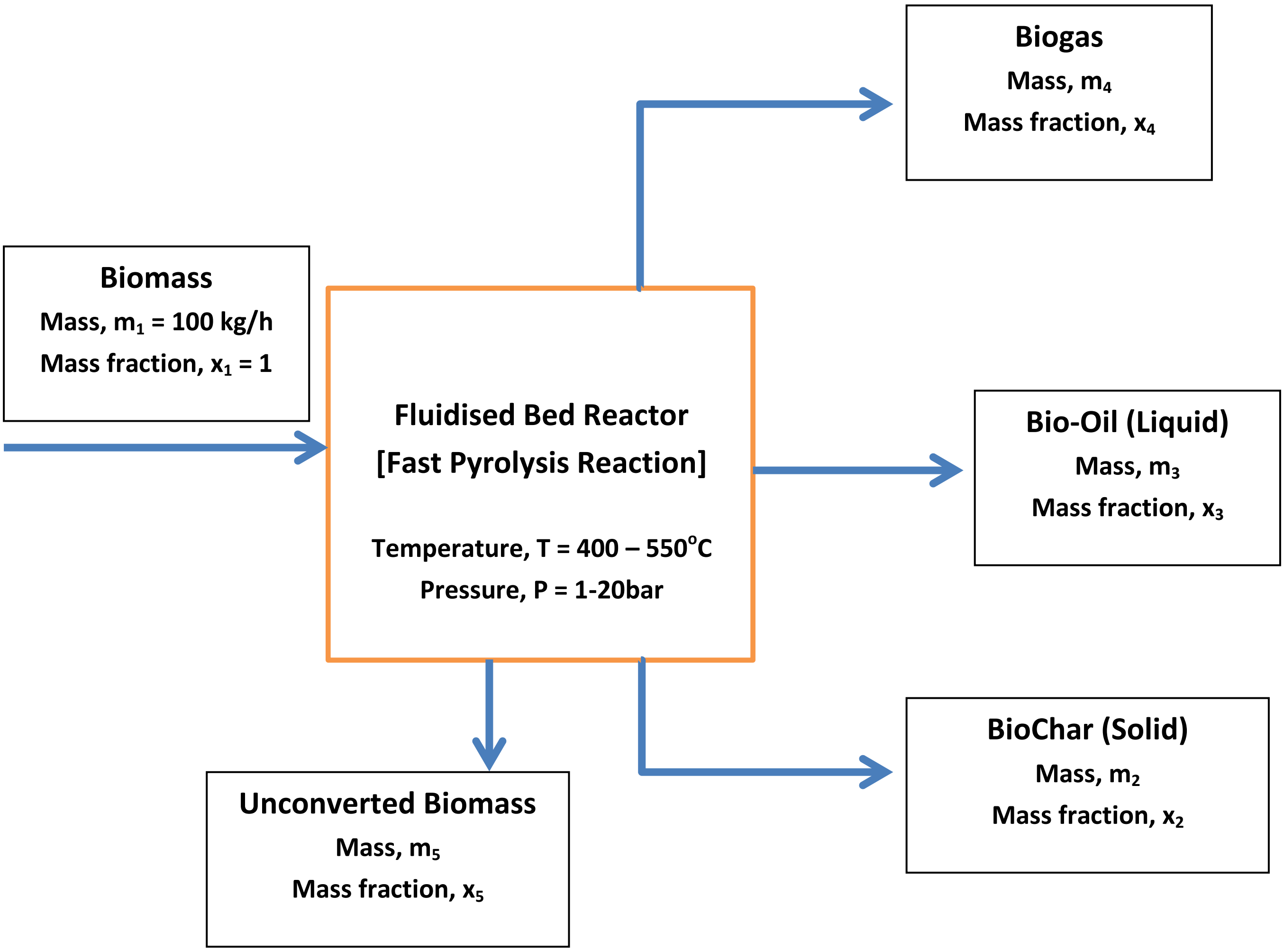
Mass Balance for Pyrolysis of Biomass



Mass Balance Equation:

{Rate of Accumulation} = {Rate of Mass Flow In} – {Rate of Mass Flow Out}

$$\frac{dm}{dt} = \dot{m}_1 - \dot{m}_2 - \dot{m}_3 - \dot{m}_4 - \dot{m}_5$$

where m_1 = mass flow rate of Biomass Feed in kg/hr
m_2 = mass flow rate of BioChar Product in kg/hr
m_3 = mass flow rate of Bio-Oil Product in kg/hr
m_4 = mass flow rate of Non-Condensable Gas in kg/hr
m_5 = mass flow rate of Unconverted Biomass in kg/hr

Brown (2009) states that the primary product from fast pyrolysis is the pyrolysis oil which is also known as **bio-oil**. Its amount is ranged from **65%-wt to 75%-wt**. The other products are **BioChar** and **Non-Condensable Gas** which are approximately **11%-wt to around 25%-wt** and **10%-wt to 20%-wt** respectively. The total biomass conversion is about 90% which means 10% biomass is unconverted.

In the technology proposed, the main component from fast pyrolysis we desire is the Bio-Oil which is a complex mixture consisting of 300 organic compounds. The major constituents of bio-oil include aldehyde (15%-wt), carboxylic acids(12%-wt), carbohydrates(8%-wt),phenols(3%-wt), furfurals (2%-wt) and ketones(3%-wt) (Brown, 2009). These are the major and basic compositions of Bio-Oil.

Non-Condensable Gas is also known as Permanent Gas.

Average percentage – Bio-Oil : 70%-wt
BioChar : 18%-wt
Non-Condensable Gas : 12%-wt

Mass Balance Calculations

It is known that the feed mass flow rate is 100kg/hr, hence

$$m_2 = 90\%\ x\ \frac{100kg}{hr}\ x\ 70\%wt = \frac{63kg}{hr}$$

$$m_3 = 90\%\ x\ \frac{100kg}{hr}\ x\ 18\%wt = \frac{16.2kg}{hr}$$

$$m_4 = 90\%\ x\ \frac{100kg}{hr}\ x\ 12\%wt = \frac{10.8kg}{hr}$$

$$m_5 = 10\%\ x\ \frac{100kg}{hr} = \frac{10kg}{hr}$$

Brown (2009) points out that for lab-scale biomass fast pyrolysis process, the biomass is fed at a rate around 0.5kg/hr to 2.0kg/hr, into the fluidised bed reactor.

Reference

Brown,J.N. (2009). Development of a lab-scale auger reactor for biomass fast pyrolysis and process optimization using response surface methodology. Digital Repository@Iowa State University : Graduate Theses and Dissertations. Paper 10996.