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Thermodynamic Modeling and Experimental Study of Wheat Husk Pyrolysis

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ABSTRACT

Pyrolysis of agricultural waste is a promising route for waste to energy generation wheat husk is a type of agro-waste that is available in plenty in India. It can be used as feed for pyrolysis to produce different products such as coke, silica, tar and syngas. The main product of slow pyrolysis is bio-char which is rich in carbon content. Another major product of pyrolysis is pyrolysis oil which can be used directly as fuel or added to petroleum feed stock and it may also be an important source for refined chemicals. Since such liquid fuels are of greater commercial interest, some researchers in the 80's found that the liquid yield can be increased using fast pyrolysis i.e. heating the bio renewable feed stock at a rapid rate followed by rapid condensation of vapors. Chemistry computer aided code for thermodynamic modeling was used to predict the products of husk pyrolysis in this research study. Slow pyrolysis of wheat husk has been carried out using microporous zeolite catalysts such as mordenite. Catalyst testing has been carried out at two positions in the reactor; one where it is mixed with the feed and other, by placing it in a catalyst boat to allow vapour phase contact. Bio-oil yields are lower in all cases of catalytic pyrolysis of wheat husk compared to thermal run. With wheat husk, most cases of catalytic pyrolysis produced more bio-oil than thermal run. The pyrolysis of wheat husk was carried out between 100-1200^{0}C in the pressure range of 1-15 bar catalyst testing has been carried out in the reactor where it is mixed with the feed and placed it in a catalyst

Keywords : Pyrolysis , Thermodynamics, Syngas , Catalyst, Microporous , Zeolite.

I. INTRODUCTION

Biomass is the main constituent of agricultural waste carbon, hydrogen, oxygen along with nitrogen and sulfur are primary component of biomass coal petroleum and nature gases are traditional carbon base fuel. This carbon based fuels are limited due to depleting reserves of fossil fuel. Biomass also contain significant amount of in organic species e.g silica.

At present the generated agro waste is use for poultry feed while the remaining is dumped into field. Conventional pyrolysis is also called as slow pyrolysis because it occurs at slow heating rate hence slow heat transfer in heating zone and long residence time bio-char is the main product of slow pyrolysis which contain high amount of carbon content. Oil is the another major product of pyrolysis which is directly use as fuel. It may be source for refined chemicals or added to feeds stock of petroleum. Black to dark red brown liquid is often from wood and called as pyrolysis oil having density 1200kg per m^3 the pyrolysis oil contain water (17 to 35 weight %). Cyclopentanone, methoxyphenol , acetic acid , methanol acetone , furfural, phenol, formic acid.Geuaiacol, levoglucosan and their alkylated phenol derivatives are the general composition of pyrolysis oil.

II. THEROTICAL STUDY

Table 1. Analysis of wheat husk

Component	% by weight dry ash free basis	Moles
C	48.69	1
H	6.97	0.855
N	0.37	0.339
O	43.94	0.0035

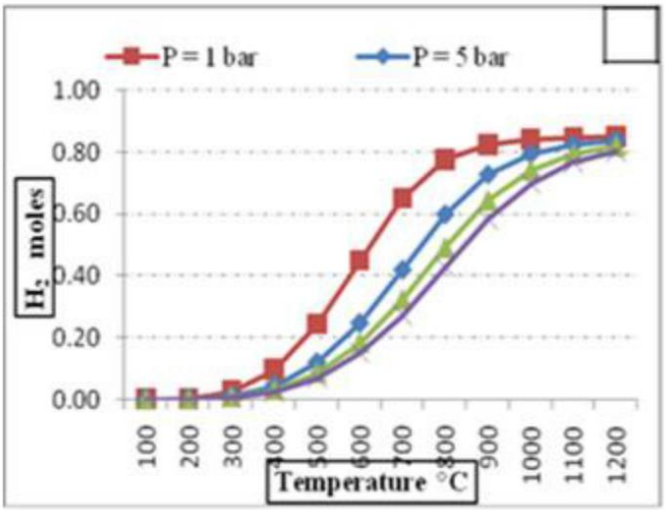
The first thermodynamic calculation considers the elements C, H, N, O, S. species and simplified systems. They contain only C, N and O were investigated. The Gibbs energy of a system is minimum. Hence it is difficult to predict the equilibrium state.

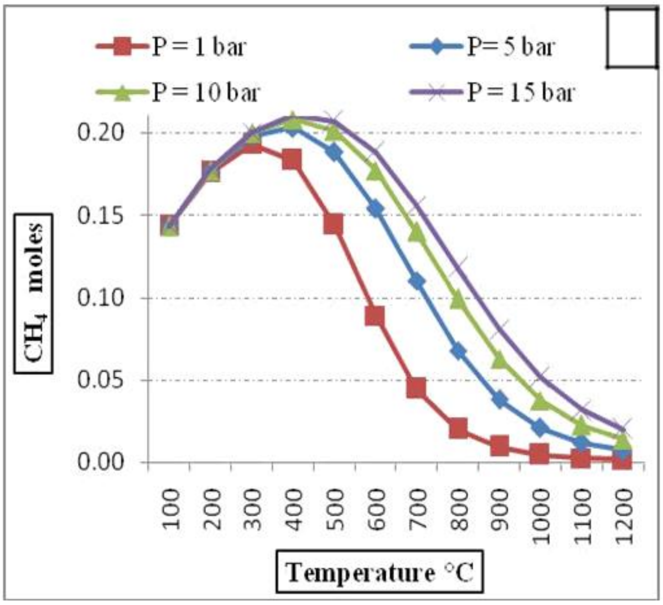
The input to the system is 1 mole contain 0.85 moles hydrogen, 0.339 mole oxygen and 0.0035 mole nitrogen . The therotical results of gas species and their fractional yield is shown in results.

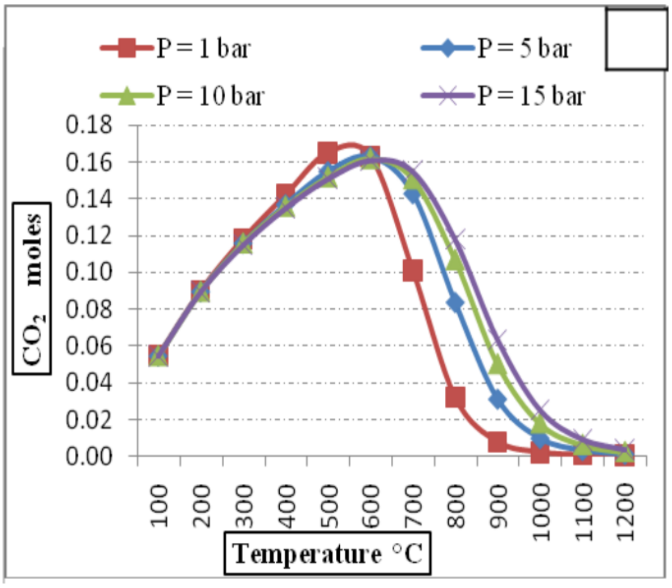
III. RESULTS AND DISCUSS

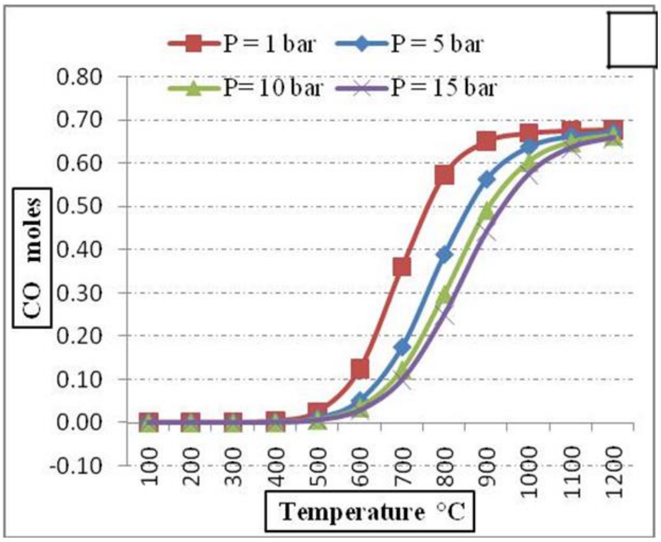
The formation of the following products in the wheat husk pyrolysis at different condition of temperature and pressure

NON AROMATIC COMPOUNDS

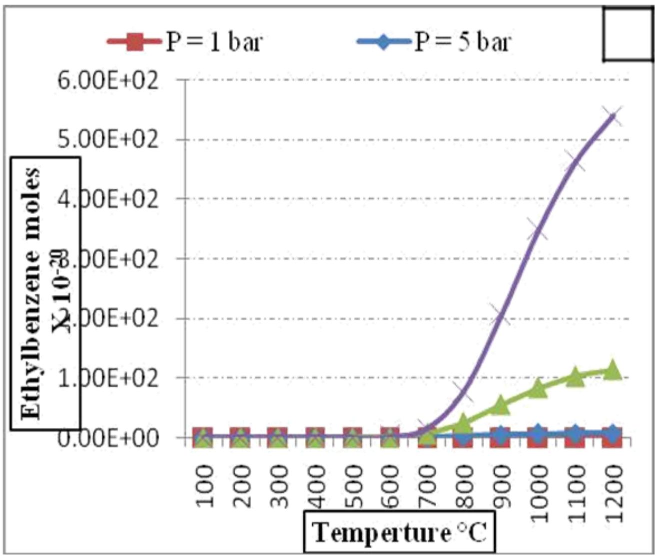




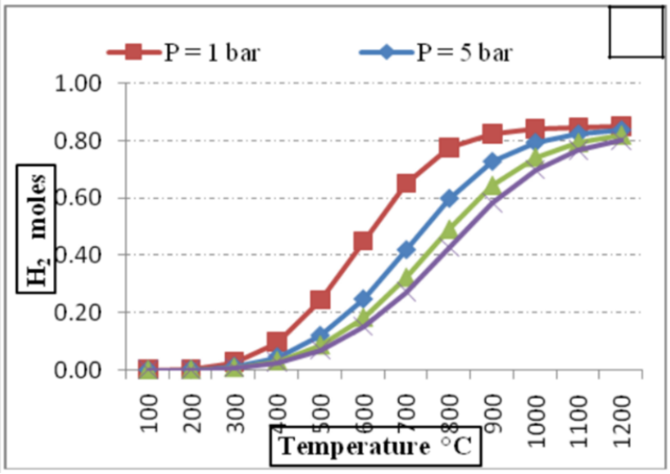


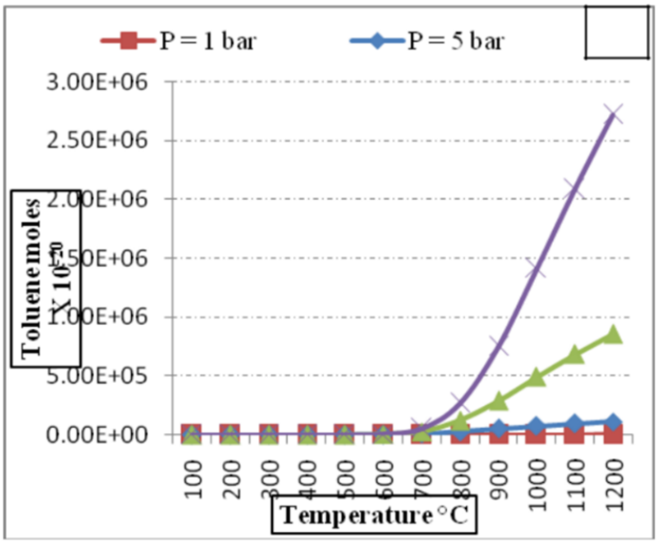


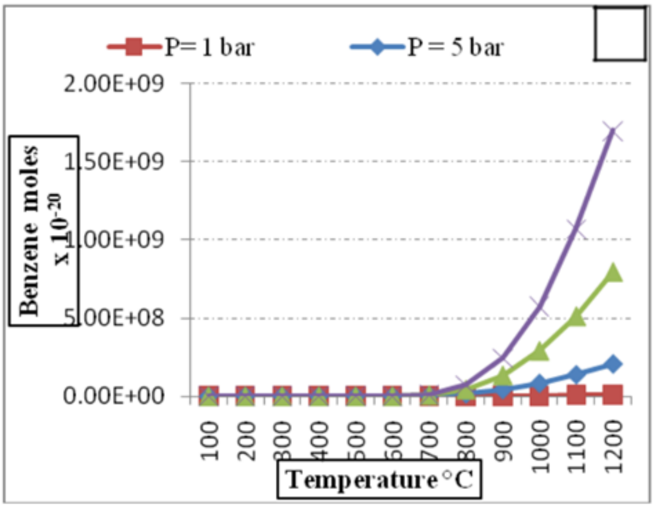
It was observed that methane and CO2 formation during pyrolysis reached a maximum between 600°C to 700°C and they gradually decreased with increase in temperature at different pressures. The effect of pressure is insignificant. higher methane formation is observed due to the higher pressure.product gas contain carbon monoxide and hydrogen increased with increses in temperature but decresed with increased in pressure.

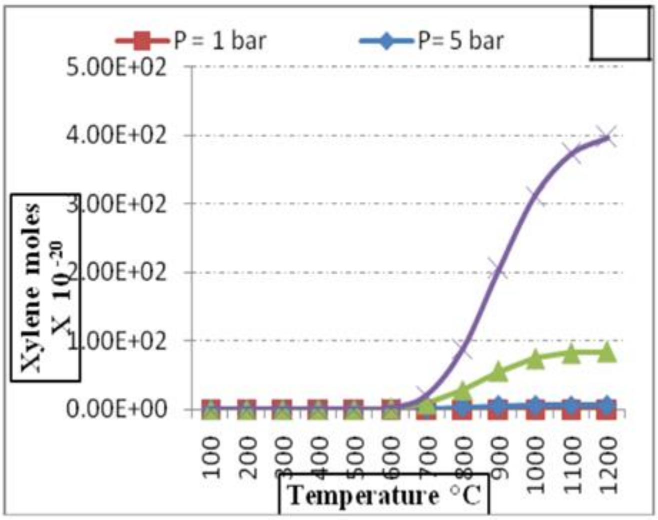


AROMATIC COMPOUNDS









The equilibrium composition of aromatic components {C6H6, C7H8, C8H10 (ethyl benzene), C8H10 (xylenes),and C6H5–OH} increased with increase in temperature and pressure

IV. EXPRIMENTAL STUDY

EXPRIMENTAL SETUP

The fixed bed reactor is used in this expriment An electric furnace used to heat Inconel reactor tube. There is a gas inlet for inert gas in reactor tube. Inner diameter 52 mm and 600 mm long are the dimensions whilwe while heated zone is 500 mm .

EXPRIMENTAL PROCEDURE

Nitrogen atmosphere is used for pyrolysis experiment. We study in this experiment about Inconel pyrolysis reactor was heated with help of furnace with auto tuning PID temperature controller . A k- type thermocouple was placed in the sample section of the furnace .

A desired input flow rate of nitrogen whice is also called as carrier gas was maintained . wheat husk sample which is about 75 gm is placed initially in pyrolysis reactor chamber . calibrated thermocouple are used to measured the temperature .And the input flow rate of N2 gas was adjusted and sample is heated up to 400^0 C . Then after products of the pyrolyser were discharged in a gas solid sepratator and passed through a chilled water condenser. The liquid products were collected in the end of experimental run . A online gas analyzer is used to analyze the gas products . The experimental was carried out at 650^0 C and also at higher pressure.

TABLE II. Wheat husk pyrolysis at corresponding reaction condition

Biomass	Initial feed weight	Optimum operating Temperature	Pressure	Residence Time
Rice Husk	75 gm	400°C	1 bar	120 min
Rice Husk	75 gm	650°C	1 bar	120 min
Rice Husk	75 gm	400°C	4 bar	120 min

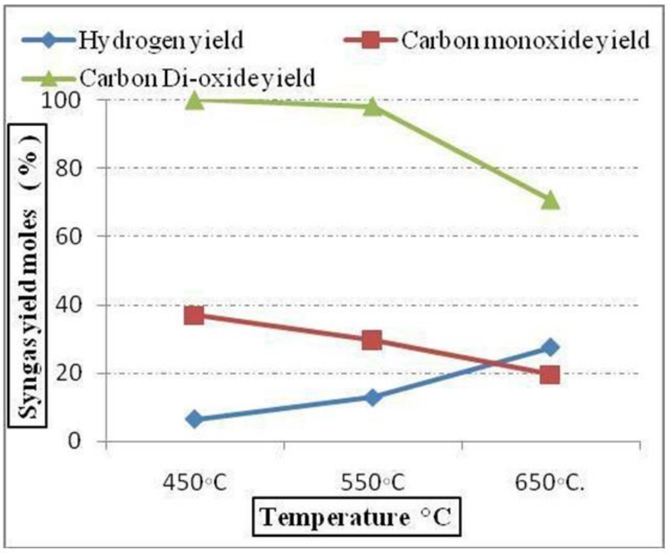
PRODUCT YIELD

Liquid pyrolysis oil, solid char , syngas are the products
obtained from the pyrolysis process.

EFFECT OF TEMPERATURE

As increased in reactor temperature from 4000C to 6500C then the experimental results showed that the liquid yield decresed . It is occurred due to secondary cracking reaction of pyrolysied vapors.

The cracking of vapors is suitable for increses in gs yield and decreses liquid yield . Also at higher temperature a decreses in char yield was observed . carbon and nitrogen percentage increses in solid char at 6500 C then 4000 C while hydrogen and sulfur content decresed was another observation.



EFFECT OF PRESSURE

It is observed that high pressur i.e 4 bar was favarable for increased in liquid yield , Upto 36.84% increses in liquid pyrolysis oil was observed in pressure

TABLE 3. Effect of pressure on Wheat husk pyrolysis at corresponding reaction condition

Feed	**Product yield (At 400°C)**	
	1 bar	**4 bar**
Rice-husk (Initial Wt = 75 gm)	Combustible Char 50 gm Combustible Liquid 12 ml.	Combustible Char 51 gm Combustible liquid 19 19 ml

V. CONCLUSION

The thermodynamic analysis of wheat husk pyrolysis showed the formation of different compounds in the system. The products were aromatic and non-aromatic in nature. The analysis indicates that aromatic fraction is not present in significant quantities in the equilibrium mixture. According to the results, the system has a high tendency to move toward thermodynamically stable species such as CH_4, CO_2, H_2O, CO, H_2, and C at equilibrium. Therefore, these aromatic products can be treated as intermediates. Pyrolysis at high pressure favours liquid oil production, where increasing in temperature increases syngas yield and decrease in char.

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