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Design and Simulation Study of Production of Syngas from Rice Husk

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Abstract: *Energy relationship in global politics has become a vital determinant. Biomass especially the rice husk is a very potential source of energy, which can be utilized in a number of ways. In India, there is an abundance of rice production as a result more of the rice husk is easily available and has a higher potential in order to fulfillments the energy requirements. Rice husk can be used to produce the syngas which is an alternative source of energy generation as compared to natural gas. As compared to natural gas, the syngas produced by the rice husk contains lesser amount of sulfur contents. We have worked out at a plant design for the synthesis of kg/h of syngas via 1000 kg/h of rice husk using fluidized bed gasification and we get 820.4kg/hr of Syngas. We have designed gasifier of length 5.94m and 1.32 m diameter having a volume of 8.115 m3. we have designed one shell pass and two tube pass heat exchanger and cyclone separator. We have done simulation of our project using Aspen Plus..*

Keywords: Aspen Plus, Rice Husk, Gasifier

I. INTRODUCTION

Biomass is more flourishing, extended and sustainable source to produce energy and other chemical products.
Keeping scarcity and environmental hazards of fossil fuels in mind, researchers are increasingly shifting their attention to renewable energy sources.
Biomass gasification is a process where biomass undergoes thermal conversion to produce a combustible gas mixture, which contains hydrogen, methane, carbon monoxide, carbon dioxide, and water vapor.
In air gasification, solid biomass is combusted partially in the presence of air at sub stoichiometric ratio and the product gas contains substantial amount of N2.[1]
In steam gasification, steam is the primary gasifying agent and the product gas is rich in H2 while N2 content is minimal. Utilizing steam as gasification agent.
The parameters that affect the performance of gasification are the gasifying agent (air or steam), gasification temperature and the size of the biomass particle.
Higher gasification temperature and small particle size are favorable for the gasification process, as they help to increase in conversion of biomass while reducing the concentration of char. [2]

1.1 Applications of Synthetic Gas (Syngas)

1.Power Generation: Syngas can be used as a fuel in gas turbines or internal combustion engines to produce electricity. It can replace natural gas or other fossil fuels, reducing greenhouse gas emissions and dependence on non-renewable resources
2. Chemical Production: Syngas serves as a crucial feedstock for the production of various chemicals. For example, it can be converted into methanol, which is used in the production of formaldehyde, acetic acid, and other chemicals. Syngas is also a starting point for the synthesis of ammonia, which is used in the production of fertilizers.[3]
3. Fuel Production: Syngas can be further processed to produce liquid fuels such as synthetic natural gas (SNG), gasoline, diesel, and jet fuels through a process called Fischer-Tropsch synthesis. These synthetic fuels can be used as a substitute for conventional petroleum-based fuels.

4. Hydrogen Production: Hydrogen is a valuable energy carrier with diverse applications, including fuel cells, chemical production, and refining processes. Syngas can be utilized as a source of hydrogen through processes like steam reforming or water-gas shift reactions.

5. Industrial Heat Applications: Syngas can be combusted to generate heat for industrial processes, such as heating furnaces, kilns, and boilers. This allows industries to reduce their reliance on fossil fuels and lower their carbon footprint.[4]

II. EXPERIMENTAL ANALYSIS

2.1 Raw Materials& Utilities

1. Rice Husk
2. Water
3. Air

2.2 Software Use for Simulation

1. Aspen Plus
2. Chemcad

2.3 Selected Method for Gasification

Dry feed is given to pyrolysis reactor, in pyrolysis reactor dry feed is burned in absence of oxygen.

After that the mixture of Ash and Air impurities is send to Cyclone separator to separate the air impurities and solid particles like ash.

The air impurities is send to combustion reactor and burned in presence of Oxygen, then the produced impure Syngas is send to gasifier rector and burned in presence of steam to react the water molecule with carbon to form carbon monoxide, hydrogen, methane, etc. products.[5]

2.4 Experimental Process

1. Input of Biomass that is Rice husk. with flowrate1000 kg per hr.
2. drying takes place in dryer.
3. dry feed and moist air separated in separator.
4. dry feed provided to reactor for pyrolysis.
5. after that solid waste that is ash is separated by Cyclone separator. And the product of pyrolysis is passed into the combustion chamber for combustion reaction.
6. Product from combustion is passed in gasifier. Gasification takes place in presence of hot steam. And Syngas is produced.
7. The gas temp is cool down with the help of cooler.
8. And Syngas and liquid get separated by separator
9. Finally, we get the Syngas in pure form that is (CO & H2).[6]

2.5 Experimental Analysis

1. Combustion Reaction

$C+1/2O_2 = CO$

$CO+1/2O_2 = CO_2$

$H_2+1/2O_2 = H_2O$

2. The Boudouard Reaction:

$C+CO_2 = 2CO$

3. Water gas Reaction:

$C+H_2O = CO+H_2$

4. Methanation Reaction:

$C+2H_2 = CH_4$

Table 1. Observations for Component Yield

Sr.No.	**Component**	**Basis**	**Basis Yield**
1	ASH	Mass	0.206
2	C(MIXED)	Mass	0.3144
3	H_2	Mass	0.0476
4	N_2	Mass	0.0056
5	S	Mass	0
6	O_2	Mass	0.4264
7	WATER	Mass	0

2.6 Observations for Biomass Analysis

Table 2. Proxinal Analysis

Sr. No.	**Element**	**Value**
1	Moisture	0
2	FC	25
3	VM	54.4
4	Ash	20.6

The proximate analysis provided contains information about the composition of a sample based on four key elements: moisture, fixed carbon (FC), volatile matter (VM), and ash.

The first element, moisture, has a value of 0, indicating that the sample is completely dry and does not contain any moisture.

The second element, FC (fixed carbon), has a value of25. This represents the percentage of carbonaceous material that remains after the volatile matter and moisture have been driven off during combustion.

The third element, VM (volatile matter), has a value of 54.4. It signifies the percentage of combustible materials that are released as gases or vapors when the sample is heated to a certain temperature.

The final element, ash, has a value of 20.6. Ash refers to the inorganic residue that remains after the combustion process. It represents the percentage of non-combustible minerals and impurities present in the sample.

In summary, the proximate analysis provides a breakdown of the sample's composition, indicating the absence of moisture, the presence of 25% fixed carbon, 54.4% volatile matter, and 20.6% ash.[7]

Table 3. Ultanal Analysis

Sr. No.	**Element**	**Value**
1	Ash	20.6
2	Carbon	31.44
3	Hydrogen	4.76
4	Nitrogen	0.56
5	Chlorine	0
6	Sulfur	0
7	Oxygen	42.64

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The ultimate analysis presented provides information about the elemental composition of a sample. the ultimate analysis provides a breakdown of the elemental composition of the sample, indicating the presence of carbon, hydrogen, nitrogen (in smaller amounts), and ash, while chlorine, sulfur, and oxygen are not detected or not present in significant quantities.[8]

Table 4. Results

Sr.No.	Component	Units	Output Mass Flow
1	H_2	Kg/hr	62.055
2	O_2	Kg/hr	0
3	N_2	Kg/hr	6.71
4	H_2O	Kg/hr	14.24
5	CO	Kg/hr	754.384
6	CO_2	Kg/hr	190.776
7	C	Kg/hr	0
8	CH_4	Kg/hr	0.0199
9	NH_3	Kg/hr	0.00189
10	ASH	Kg/hr	0

Table 5. Sensitivity Analysis

Sr.No	Gasifier Temp	CO	CO_2	H_2
1	800	0.3559	0.0857	0.4531
2	900	0.3691	0.0727	0.4443
3	1000	0.3784	0.0633	0.4354
4	1030	0.3808	0.0609	0.4330
5	1100	0.3858	0.0560	0.4281
6	1200	0.3916	0.0502	0.4223
7	1300	0.3963	0.0455	0.4176
8	1400	0.4001	0.0417	0.4138
9	1500	0.4032	0.0386	0.4107

By using above sensitivity analysis we conclude that the as we vary gasifier temprature we get corresponding value of carbon monoxide, carbon dioxide and hydrogen. And we get the optimum value of gasifier temprature 1030. [8]

2.7 Graphical Representation for Sensitivity Analysis

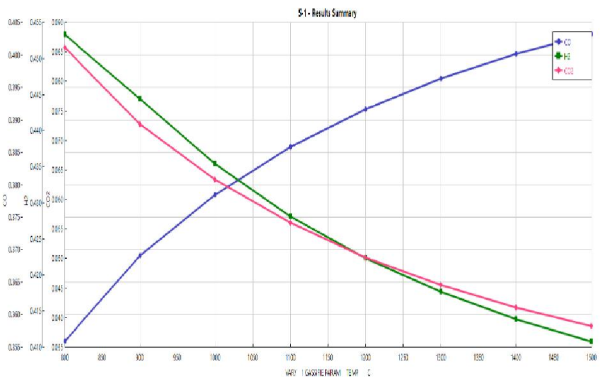

Fig 1. Sensitivity Analysis

Fig.showsthe graphical representation of Sensitivity analysis for the recovery of Carbon monoxide, Hydrogen and Carbon dioxide.

The blue line is for CO,Green for H_2,

Pink is for Carbon dioxide.

III. CONCLUSION

Simulation of Rice Husk gasification in gasifier using Aspen plus.

The effect of gasification temperature, equivalence ratio, moisture content, carbon dioxide produced has been discussed.

The gasification temperature is found to have a strong influence on the syngas composition.

Increasing the temperature improves gasifier performance, enhancing the production of H2 and CO in syngas.

Thermodynamic equilibrium models and kinetic models were utilized for modeling and simulation purposes. Computational tools were employed to simulate the syngas production process, allowing for a comprehensive analysis of system performance. The results of the simulation provided valuable insights into the syngas yield, energy efficiency, and environmental impact.

In conclusion, this design and simulation study provides valuable insights into the production of syngas from rice husk. The results emphasize the potential of utilizing rice husk as a renewable energy feedstock, contributing to sustainable energy production and waste management. Further research and development in this area will help in overcoming challenges and realizing the full potential of rice husk gasification for syngas production.

This steam produced can be divided into two portions one of it can be used as a gasification medium in the gasifier, while the remaining portion can be used to run the turbine. The steam produced will run the blades of the turbine as a result of which thermal energy will be converted into mechanical energy.

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