Modeling, Simulation and Control of a Biomass Gasifier

Major Project Report

Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Technology

In

Instrumentation & control Engineering

(Control and Automation)

By

Nihal Dalwadi
(14MICC08)

Instrumentation & Control Engineering Section
Department of Electrical Engineering
Institute of Technology
NIRMA UNIVERSITY
AHMEDABAD 382481

MAY 2016

Modeling, Simulation and Control of a Biomass Gasifier

Major Project Report

Submitted in Partial Fulfillment of the Requirements for the Degree of

MASTER OF TECHNOLOGY

IN

INSTRUMENTATION & CONTROL ENGINEERING

(Control and Automation)

By

Nihal Dalwadi

(14MICC08)

Under the Guidance of

Prof. Alpesh Patel & Prof. Darshit Upadhyay

Instrumentation & Control Engineering Section

Department of Electrical Engineering

INSTITUTE OF TECHNOLOGY

NIRMA UNIVERSITY

AHMEDABAD 382481

MAY 2016

Declaration

This is to certify that,

i. The thesis comprises my original work towards the degree of Master of Technology in Control and Automation at Nirma University and has not been submitted elsewhere for a degree

ii. Due acknowledgement has been made in the text to all other material used.

Nihal Dalwadi

Undertaking for Originality of the Work

I, **Nihal Dalwadi (14MICC08)** give undertaking that the Major Project entitled **"Modeling, Simulation and Control of a Biomass Gasifier"** submitted by me, towards the partial fulfillment of the requirements for the degree of **Master of Technology** in **Instrumentation and Control Engineering (Control and Automation)** of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

Date -
Place - Ahmedabad

____

Student
Nihal Dalwadi
14MICC08

Endorsed By

Project Guide	**Project Co-Guide**
Prof. Alpesh patel	Prof. Darshit Upadhyay

Certificate

This is to certify that the Major Project Report entitled **"Modeling Simulation and Control of a Biomass Gasifier "** submitted by **Mr. Nihal Dalwadi(14MICC08)**, towards the partial fulfillment of the requirements for the award of degree in **Master of Technology (Instrumentation and Control Engineering)** in the field of **(Control and Automation)** of Nirma University is the record of work carried out by him under our supervision and guidance. The work submitted has reached a level required for being accepted for examination. The results embodied in this major project to the best of my knowledge have not been submitted to any other University or Institution for award of any degree or diploma.

Date - May 2016

Internal Guide	**Co. Guide**
Prof. Alpesh Patel	**Prof. Darshit Upadhyay**
Assistant Professor (I & C)	Assistant Professor(Mech.)
Institute of Technology	Institute of Technology
Nirma University	Nirma University
Ahmedabad	Ahmedabad

Program Coordinator	**Head Of Department**	**Director**
Dr. J.B Patel	**Dr. P.N Tekwani**	**Dr. P.N Tekwani**
Institute of Technology	Institute of Technology	Institute of Technology
Nirma University	Nirma University	Nirma University
Ahmedabad	Ahmedabad	Ahmedabad

Acknowledgements

First and foremost thanks to almighty for being kind and merciful, I would like to extend my deepest gratitude to my guide Prof. Alpesh Patel (Assistant Professor, I&C) and Prof. Darshit Upadhyay((Assistant Professor, Mech.) who gave me the freedom to explore on my own, and at the same time the guidance to recover when my steps faltered, I would also like to thank Dr.P.N.Tekwani(HOD,EE & Director, ITNU), Dr.Dipak M.Adhyaru (Section Head, I & C), Dr.Jignesh B.Patel (Sr. Asso. Professor & Program Coordinator, I&C) and Dr.R.N.Patel (HOD, Department of Mechanical Engg.)for their help & support. Furthermore I would like to thank whole faculty and staff members of Instrumentation & Control Engineering Section for their timely assistance.
Finally, this wouldn't have been possible without constant support of my family to whom i dedicate this work.

- Nihal Dalwadi
14MICC08

Abstract

A developing country like INDIA has massive energy demands. Coal based power plants generates approximately 60% electricity in INDIA. These power plants generate pollution and cause the greenhouse effect, global warming etc. CFA (2014-2015) (Central Electricity Authority) reported that 25894 villages in INDIA are still not electrified and not connected with power grid. 68 % of population is living in country side and people are mainly depending on farming and animal husbandry. Gasification is one of suitable way for off grid rural electrification as fuel flexibility is major advantage of gasification. Gasification is converting the solid biomass into producer gas.

This project involves the thermodynamic equilibrium modeling, simulation and conventional controller design using LabVIEW and Matlab platform. Simulation has been carried out using Newton-Raphson method for widely available biomass in INDIA. Among all, cotton stalks has highest amount of hydrogen (23%) and municipal waste has lowest amount of hydrogen (11%) in syngas composition. GUI is developed using Matlab platform for estimate the moisture effect on the produce gas composition at temperature is 1023K and 0.25 ER also for user define ultimate analysis. Empirical data is used to develop static model to design a controller for gasifier. 10 kWe downdraft gasifier is available with the financial support of Department of Science and Technology (DST), Government of INDIA. DAQ (Data Acquisition System) is developed using Arduino Uno and LabVIEW (VISA) for the available gasifier system. System identification tool is used for system identification and based on in conventional controller is design. PI control mode is batter for control the gasification process.

List of Figures

Contents

Chapter 1

Introduction

1.1 Importance of Gasification

Incomplete combustion of biomass in called gasification. It will generate gas Mixture which contains carbon monoxide (CO), hydrogen (H_2), a few amount of methane (CH_4). This combination is called producer gases or syngas (synthesis gas).it can be used to substitute of furnace oil, run internal combustion engine or directly used in thermal application.in sparingly viable way. Biomass gasification is thermo-chemical process which gives a clean and hydrogen rich syngas.

1.2 Importance of gasification

Because of syngas is produced by gasification may be taken place of generation of electricity by natural gas. Which save very low power and fertilizer industries in india .In addition coal gasification can be used as south Africa has successfully demonstrate for more than 50 years to create very large volume of clean syngas. Thats why gasification take place of natural gas and petroleum. This is enough reason to encourage wide spread and rapid deployment of this technology. These are reasons why gasification is technology use for more and more.

1) Syngas is a cleanest gas to be used in an IGCC power plant. So it is possible to virtually eliminate emission if an air pollution and harmful pollutants.

2) The production of a syngas is more cost effective then the any other like natural

gas. So production of energy using syngas is cost effective.
3) Hydrogen and carbon monoxide are generated in gasification process. This is the only conventional energy technology to generate a huge amount of H_2 gas.

1.3 Motivation

Energy demand is increasing consistently in INDIA. Leading source of energy is fossil fuel nowadays and even continue in future. Demand of fossil fuel is increasing due to the fast development of fossil fuel resource which opposing conservational effect causing global warming. So worldwide researcher have been explore a renewable energy like wind, solar, biomass, tilde etc. among all there energy source, biomass is a clean cheap and widely available energy source. In rural area, combustion in ambient air (direct) is popular. It is not good for the environment aspect, human health aspect and thermal efficiency. Gasification is better in all aspect as compared to direct combustion as it can operate with all major carbonaceous fuel.

1.4 Objective of the Study

To study of downdraft biomass gasifier to predict the behavior and effect of moisture content on producer gas composition at constant temperature and equivalence ration based on
1) Thermodynamic modeling and simulation
2) Static modeling
3) Dynamic modeling
4) GUI

1.5 Justification for taking this project

In INDIA, approximately 25894 villages are not electrified and not possible/feasible to connect all villages vie power grid. According to ministry of coal, government of INDIA 45million tones is import in 2014-2015. Gasification is batter option there

to generate electricity. In India 2521.88 MW power generated using gasification. Biomass is widely available in INDIA so electricity generation can be increases.
10 kWe downdraft gasifier is available in Mechanical Engineering Department, Institute of Technology, Nirma University. Automation is required for this setup. Project has been taken for controlling and simulation of available setup.

1.6 Organization of thesis

Chapter 2 deals with the literature survey of biomass gasification process and prediction of producer gas composition.
Chapter 3 deals with the gasification process. All four zone, drying, pyrolysis, combustion and reduction zone are explained with necessary diagrams. Thermodynamic equilibrium model is in the chapter. This thermodynamic modeling contains Mass balance, energy balance and gas composition equations and algorithm to solve these equations.
Chapter 4 deals with the static modeling of the downdraft biomass gasifier. This static model has two controlled variable temperature in the gasifier and the CO/CO_2 ratio of the syngas where manipulated variable is frequency of greet and air flow. This model is developed using mathematical process on the practical data. The basic DAQ (data acquisition system) developed using arduino Uno, k type thermocouple and LabVIEW platform. System identification and controller design. Dynamic modeling is done using the Matlab ident tools and Simulink. Controller is design using z-N tuning method.
Chapter 5 deals with the GUI (graphical user interface). This GUI contains an ultimate analysis, HHV (Higher Heating Value) of biomass, effect of moisture content on syngas composition.
Chapter 6 concludes remarks and future scope

Chapter 2

Literature survey

Many theoretical and practical works in gasification and their thermodynamic modeling had been done and available. Main aim of is to understand the thermochemical process while gasification with influence of the moisture content, temperature and equivalence ratio. Z.A. Zainal et al [1] is proposed a thermodynamic model of the downdraft biomass gasifier to predict the syngas composition. Hydrogen and carbon dioxide is decreases when the moisture content of the biomass is increases. Calorific and temperature is reduced with the moisture

Marcelo Echegaray et al [2], proposed steady state modeling. H_2 rich syngas is produced by the waste gasification. The value steam + air flow is very and study the effect of in on a syngas composition at constant temperature (800 K) ER = 0.25. CV is at maximum at 1023 K to 1073 K temperatures. Molar fraction of the H_2 and CO is low. Syngas quality is high when steam and air mixture is used instead of only air. Widely available biomass bamboo, Shisham, Gulmohar, neem, and Dimaru are used as a fuel in a gasification process P.P Dutta et al [3] Bamboo has high carbon content (18.4 MJ/Kg). Gulmohar has a highest value of hydrogen in syngas. Dimaru has a higher volatile meter (15.95 MJ/Kg). Bamboo has Highest CV among all. Dimaru has lowest. And shisham has high Hydrogen and good CV. (15.15 MJ/Kg).

C. sagues at al. [4] suggested fuzzy controller for biomass gasifier. While fuzzy implication system does not need models (plant model) to be tuned. Human input is needed to input a data to the controller (only moisture content). All the parameter set according to the input. This fuzzy controller is control biomass gasifier efficiently with compare to conventional controller.

Koroneos C et al [5] has done thermodynamic modeling for the downdraft biomass gasfier. Steady state modeling is done for the Oil-Palm Fronds using ASPEN PLUS Samson Mekbib Atnaw et al. [6]

T.H. Jayah at al. [7] had done a computer program for of downdraft biomass gasifier for tea drying. Avdhesh Kr. Sharma [8] is developed EQR computer program to predict the steady state performance of the downdraft biomass gasifier.

Ratnadharya J.K [9] is proposed three zone equilibrium and kinetic free modeling of biomass gasifier a-novel approach which gives the operating range of equivalence ratio and moisture content of the woody biomass materials and also provides useful information for design a gasifier and selection of material for their erection. Anred Melgar et al [10] proposed thermochemical equilibrium model in which they describes that reaction temperature is a parameter that driven all the gasification process. Simulation of wood waste (saw dust) gasification using an equilibrium model is proposed by Altafini Carlos R. et al [11] which is based in the Gibbs free energy. Baratial M. et al [12] is presented model which has been applied both to partial oxidation and steam gasification process with varying air to biomass and steam to carbon ratio values and using different duel.

Chapter 3

Biomass Gasification Process

Biomass gasification process is a district process take place in a gasifier.

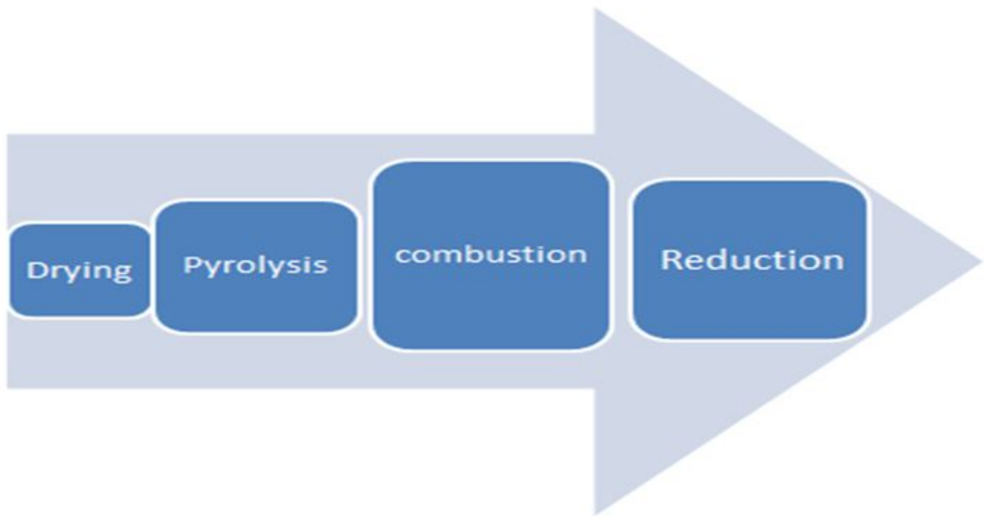

Figure 3.1: Flow diagram of Gasification Process

1) Drying

All biomass content moisture and it has to be removed before combustion can take place. The radiation of a combustion zone is supply the heat for the drying process. And some amount of heat is store for only drying perpose

2) Pyrolysis

The temperature of a biomass is reaches up to 250C the volatile gases are released.

It has carbon dioxide (CO_2), carbon monoxide(CO), methane (CH_4), hydrogen and Tar. Tar is condensing to a liquid if cold. This gas is mix with O_2 from air and burn with a yellow flame. This process is give a heat to drying process. Oxygen has to be providing to sustain this part of the combustion process. Char is the remaining material after all the volatiles have been burned off.

3) Combustion

It is an exothermic reaction of hydrocarbon with O_2. This heat is generated from the combustion of tar that is produced in pyrolysis zone. This is called oxidizing. To reduce the CO_2 and H_2O in reduction zone and to run the reduction process the combustion is done. Tar of tar gas will be fuel of the combustion process. To aim to combustion in downdraft is to get good mixing and high temps so that all the tar are either burned or cracked and thus will not present in the out coming gas.

4) Reduction

IN this process taking off oxygen atoms off completely combusted hydrocarbon (HC) molecules, so as to return the molecules to form that can burn again. It is a directly inverse process of combustion. In steady state condition both combustion and reduction process done simultaneously. Reduction process is done by the passing of CO_2 and H_2O across the char bed. The hot chat is highly reactive with the oxygen thus strips he oxygen off the gasses and redistributes it to as many single bounds sites as possible. The oxygen is more attracted to the bound site on the carbon then to itself, thus no free oxygen can available C sites as individual O, until all atoms the oxygen is gone. When all free atoms of oxygen is redistributed as a single atoms, reduction stops.

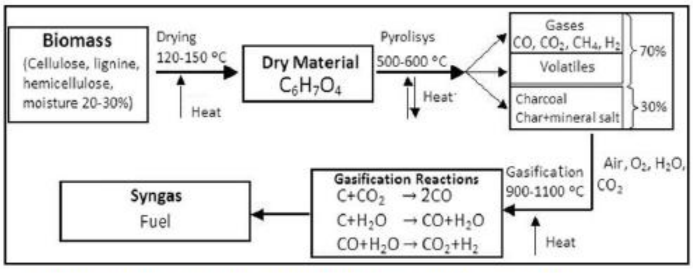

Figure 3.2: Block diagram of gasification process [7]

3.1 Thermodynamic equilibrium modeling

This thermodynamic modeling is based on the Zinal model which content carbon, Hydrogen and oxygen only [1]. Thermodynamic model gives a maximum conversion of the reactance. Normally it achieved at high temperature (800K to 1200K). The basic assumption is required for the thermodynamic model. Reactions in the gasification process are as below,

$C + CO_2 = 2CO$ ....(3.1)

$C + H_2O = CO + H_2$....................(3.2)

$C + 2H_2 = CH_4$ ....(3.3)

Eq. (3.1) and (3.2) can be joint to give shift reaction

$CO + 2H_2 = CO_2 + H_2$ ....(3.4)

$K1 = P_{CH4}/P^2_{H2}$....................(3.5)

$K2 = P_{CO2}P_{H2}/ P_{CO}H_{2O}$ ....(3.6)

The typical chemical formation of wood material, based on the single atom of carbon $C\ H_a\ O_b$.

The global reaction of the gasification of reaction is written

CH_aO_b + wH_2O + m (O_2+3.76N_2) = x1H_2 + x2CO + x3CO_2 + x4H_2O + x5CH_4 + 3.6 mN_2...................... ....(3.7)

Let MC=moisture content per mole wood.

MC=24w/18(1-w) ....(3.8)

Where w is the amount of water, m, the amount of oxygen per mole of wood, X1 to X5, the coefficient of the constitutes of the product. For the know moisture contact, the value of w become a constant and m can be founding from the airflow rate per mole of wood.

Carbon Balance:

$1 = x_1 + x_3 + x_5$....................(3.9)

Hydrogen Balance:

$2w + a = 2x_1 + 2x_4 + 4x_5$....................(3.10)

Oxygen balance:

$W + b + 2m = + 4x_4 + x_5$....................(3.11)

Equilibrium constant form methane formation (Eq. (3.3))

K1 = $x_5/{x_1}^2$...(3.12)

$From Eq.$(3.9)

x_5 = x_1 + x_3 - 1...(3.13)

From Eq. (3.10)

x_4= w + 0.5a - x_1 - 2 x_5 ....(3.14)

Substitute the value of x5from the Eq. (3.9) in to Eq. (3.10)

x_4= - x_1+ $2x_2$+ $2x_3$+ w - 1.28 ....(3.15)

From Eq. (3.11)

${x_1}^2 K1 = 1-$$x_2$ -x_3 ....(3.16)

Substituting the value of from the Eq. (16) in to Eq.(11)

$x_1 x_3$ = k2x_2 [-x_1 + $2x_2$ + $2x_3$ + w - 1.28]..(3.18)

The question for the heat balance for the gasification process,

Assumed to be adiabatic is:

The general equation for k1 and k2 is:

lnK1=7082/T+ 7.466*$10^-3T/2+-2.164+10^-6T^2/6+0.701*10-5/2T^2+32.541$............(3.19)

$lnK2 = 5870.53/T+1.86lnT-2.7*10^-4T58200/T^2-18.007$.......................................(3.20)

$The equilibrium constant K1 and K2 for any teamperature (T)$

$can be solve by equestion$(19)$and$(20).

$T2 = T1 + dT$

Where dT is a temperature change because of gasification

The set of question (13) to (17) can be solved using following algorithm.

1) Specify the value of moisture content (m) and water per mole (w).

2) Adopt temperature T fined K1 and K2 using Eq. (19) and Eq. (21).

3) Find x_4 , x_1 and x_3 using Eq.(14), Eq.(15)and Eq.(16) individually

4) Find x_4 and x_5 using Eq. (9) and Eq. (16) respectively.

5) Compute the new value of T.

6) Recurrence the above steps until continuous value of T become constant.

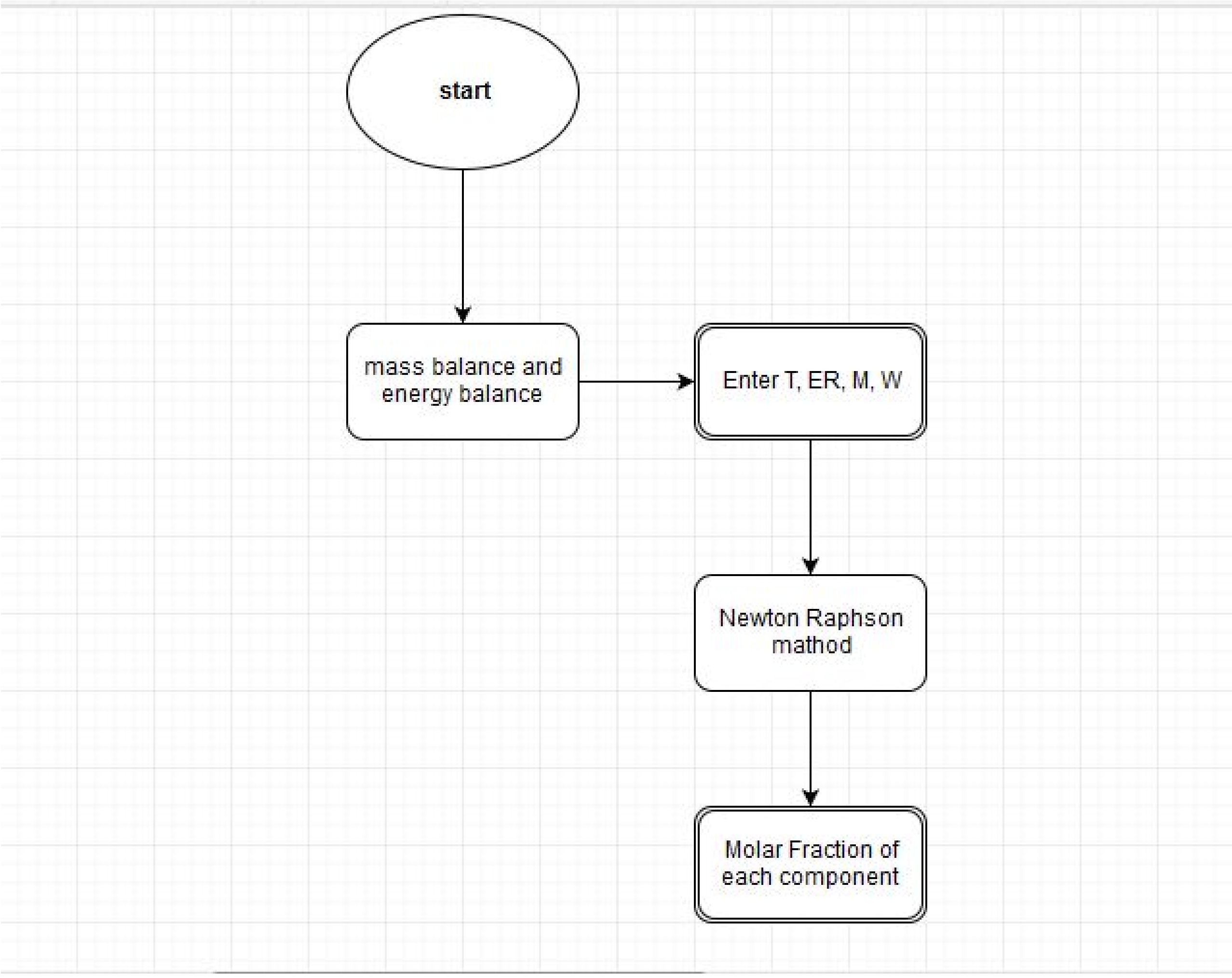

Figure 3.3: The Calculation procedure

For calculating the molar fraction of the syngas, first initialize the temperature of the combustion zone, value of the ER, water per mole of a biomass. After it put the value in a mass balance and energy balance equations and apply Newton Raphson method for solving these questions. Put the value in equations and get the molar fraction of the syngas.

Chapter 4

Static Model of a Biomass Gasifier

It is hard to make accurate model of the non-linear system like gasification process. Plant model of a biomass gasifier is for control purpose, based on the experimental data. Some mathematical process is done for adjusting data to the trial data Shown in the experimental data of the biomass gasifier.

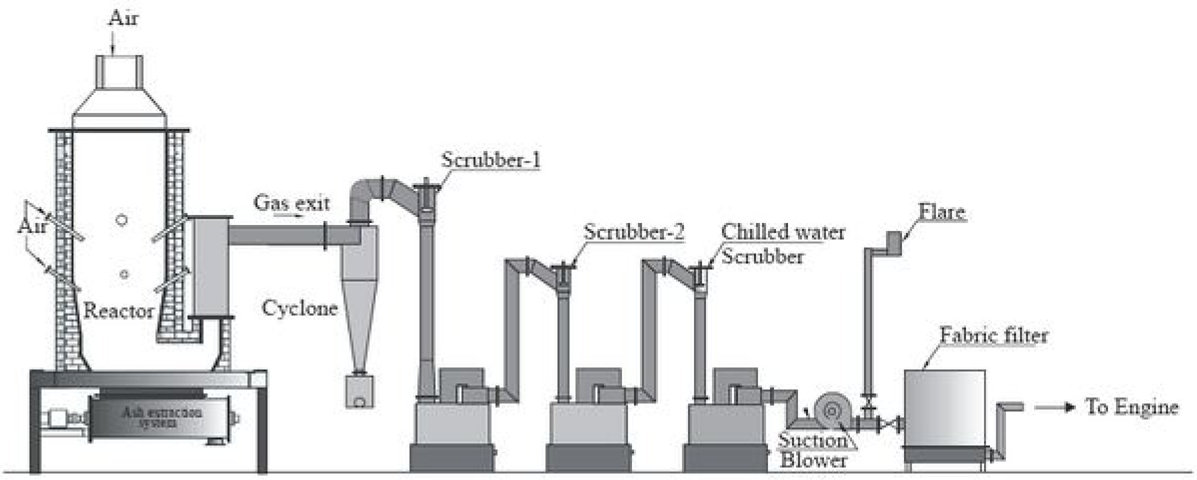

Figure 4.1: Biomass gasification plant for energy generation [24]]

	A	B	C	D	E	F	G	H
1	FA	Fg	ER(%)	Fc	Hm(%)	Temp.	CO/CO2	
2	3	0.006	0.3348	1.69	7.5	720	0.17	
3	3.9	0.006	0.4358	1.65	7.5	760	0.31	
4	4.8	0.006	0.5316	1.69	7.5	628.2	0.35	
5	5.7	0.006	0.6232	1.73	7.5	629.2	0.5	
6	6.3	0.006	0.7152	1.77	7.5	633.3	0.5	
7	6.9	0.05	0.7324	1.81	7.5	594.4	0.81	
8	12	0.05	0.8643	1.85	7.5	810	0.78	
9	18	0.08	0.1143	1.79	7.5	860	1.6	
10	21	0.08	0.125	1.81	7.5	900	1.9	
11	22	0.085	0.1243	1.85	7.5	910	2.1	
12	24	0.09	0.1432	1.86	7.5	920	2.2	
13	25	0.095	0.152	1.9	7.5	924	2.4	
14	3	0.006	0.1603	1.98	20	655	0.28	
15	3.9	0.05	0.1643	1.97	20	640	0.29	
16								

Figure 4.2: Plant Data [4]

Four sub-systems were developed in MATLAB.

1) Biomass Consumption (FC) It is the total of a biomass combustion for the gasification process. It is related with the flow rate (Fr), frequency of the rotations of the grate (Fg) and moisture content (Hm). Below, the Simulink model of biomass consumption. The exact expression is,

FC = [77*10-3*F / Hm0.33] +15*10-1 +fg

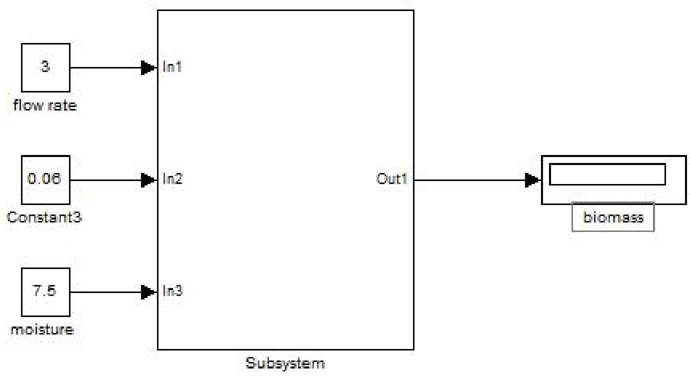

Figure 4.3: Biomass consumption

It can be observed from the graph that, a biomass consumption decrease when that moisture content increasing.

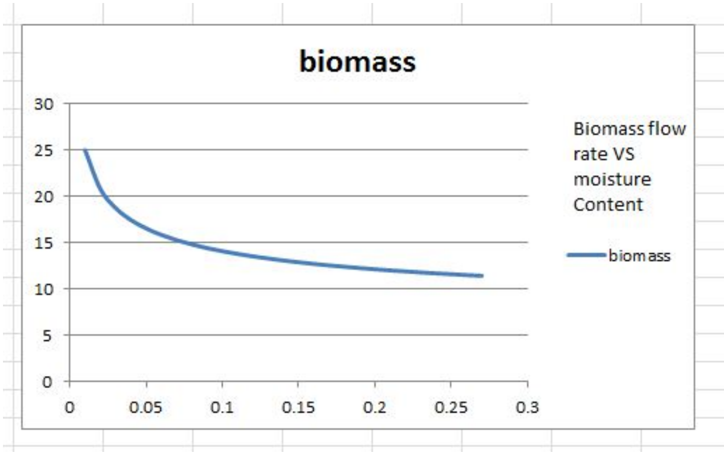

Figure 4.4: Biomass vs. Moisture content

2) Equivalence ratio (ER) It is related on a biomass consumption, flow rate and moisture content and the type of material used as a biomass material factor Mf (air needed for combustion the 1Kg of dry biomass). Simulink model of this is given below.

ER% = [F/(2547*10-1)*Fh(H-1)*Mf]*1000

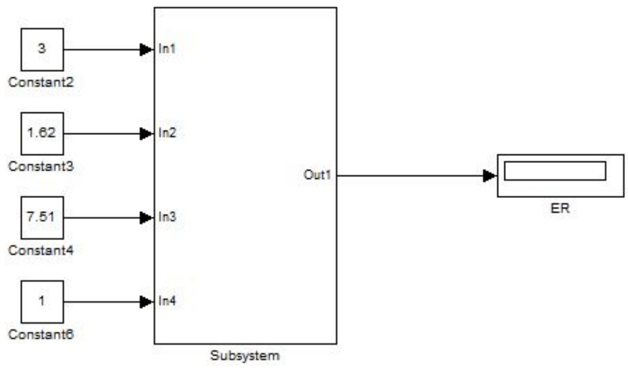

Figure 4.5: Equivalence Ratio Module

3) CO/CO_2 Ratio

CO/CO2 ration is controlled variable. it depends on the moisture content and equivalence ration of the fuel and air.

CO/CO_2 ratio = (30*10-3*Hm+1/2)*ER (%)-2761*10-4

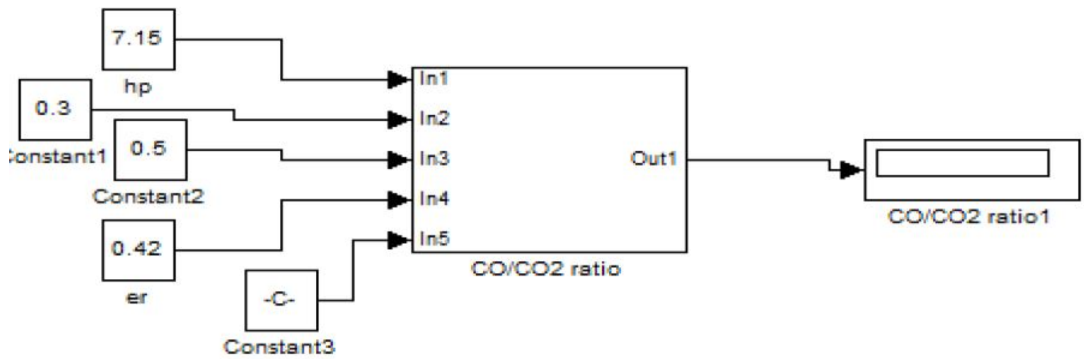

Figure 4.6: Ratio of syngas

4) Temperature(T)

Temperature is depends on the quality of a biomass material (Mc), ER, Hm and FC. The equation is given below.

T= Ma*ER + 330*10-1/H + Mc +220 + 100*ER +1000*fg

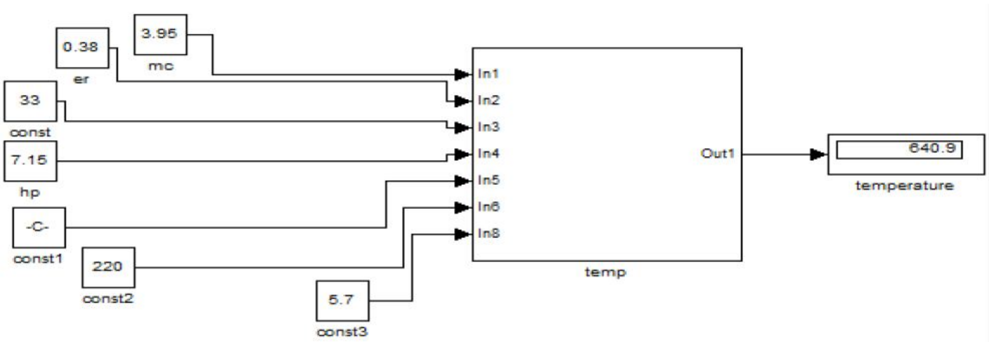

Figure 4.7: Temperature Module

This static model is developed using some mathematical process on trial data of a plan. Using this model advance control algorithm is also developed. Temperature and CO/CO_2 ratio is a controlled variables and frequency of greet and biomass flow rate is manipulated variables. Moistrure Content is distrubance in biomass.

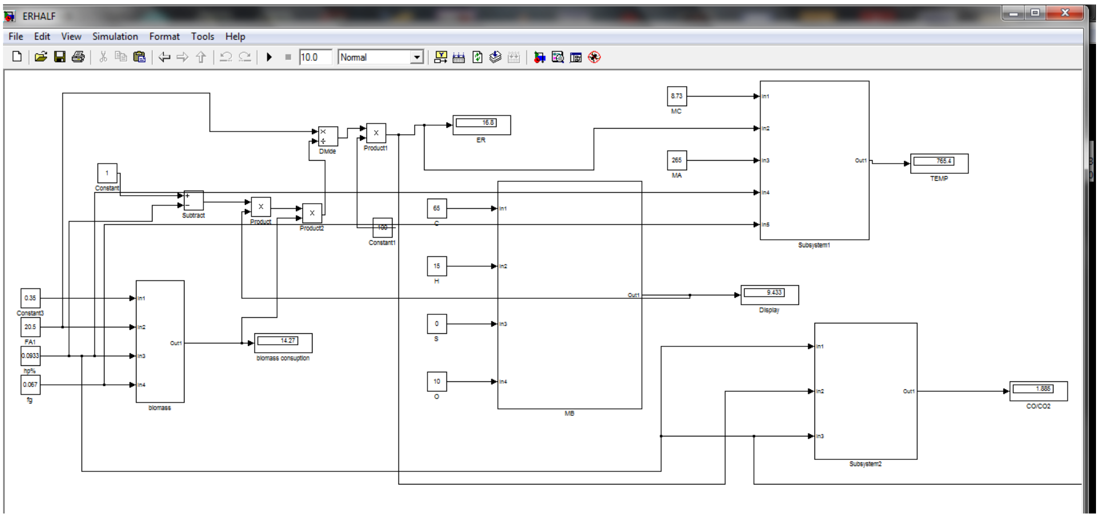

Figure 4.8: Static Model for Gasifier

4.1 Dynamic Modeling

Dynamic modeling is a time dominion characteristics of the system. Dynamic modeling is used for study of the behavior of the system. Dynamic modeling of a biomass is done using system ident tool in Matlab. First basic data Acquisition system of biomass gasifier is developed.

4.1.1 DAQ (Data Acquisition System)

This is a schematic diagram of the data acquisition system of biomass gasifier. For the DAQ, K type thermocouple, MAX6657, and turbine type digital air flow meter is used.

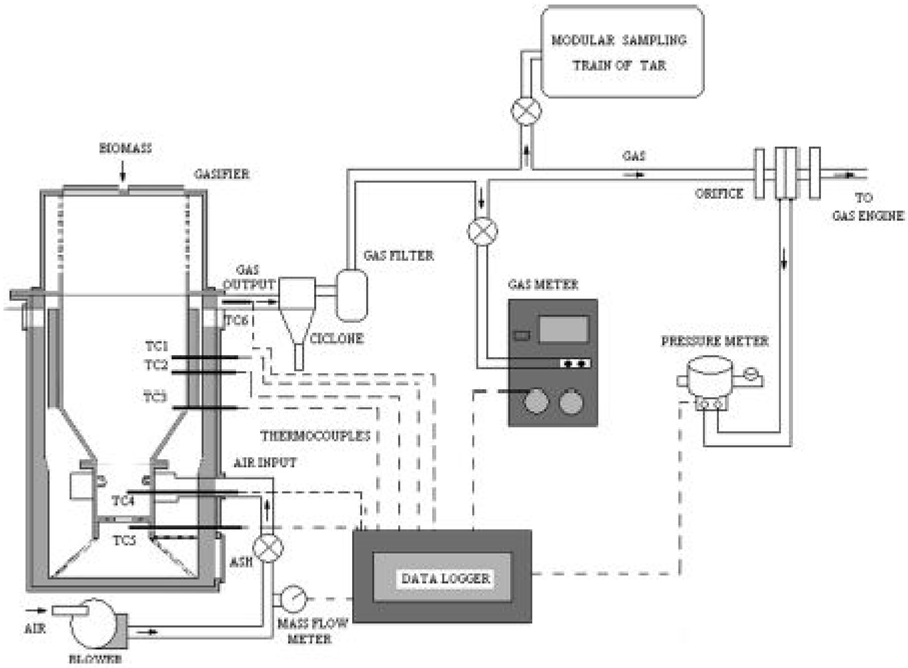

Figure 4.9: Schematic diagram of the DAQ[19]

Serial communication between Arduino uno and Labview had done using VISA.

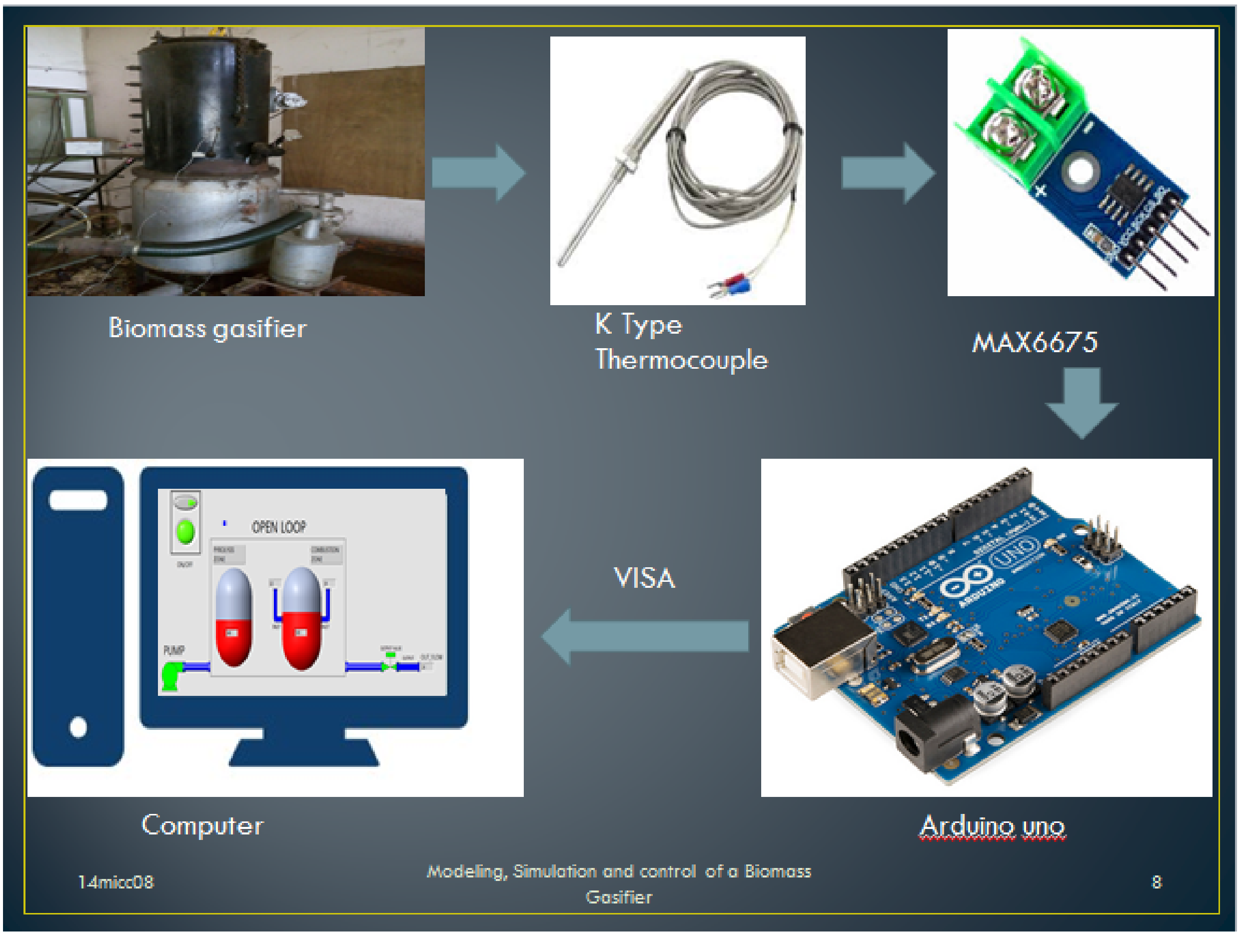

Figure 4.10: Block diagram of the DAQ

Store data of Microsoft excel for farther analysis to design the controller.

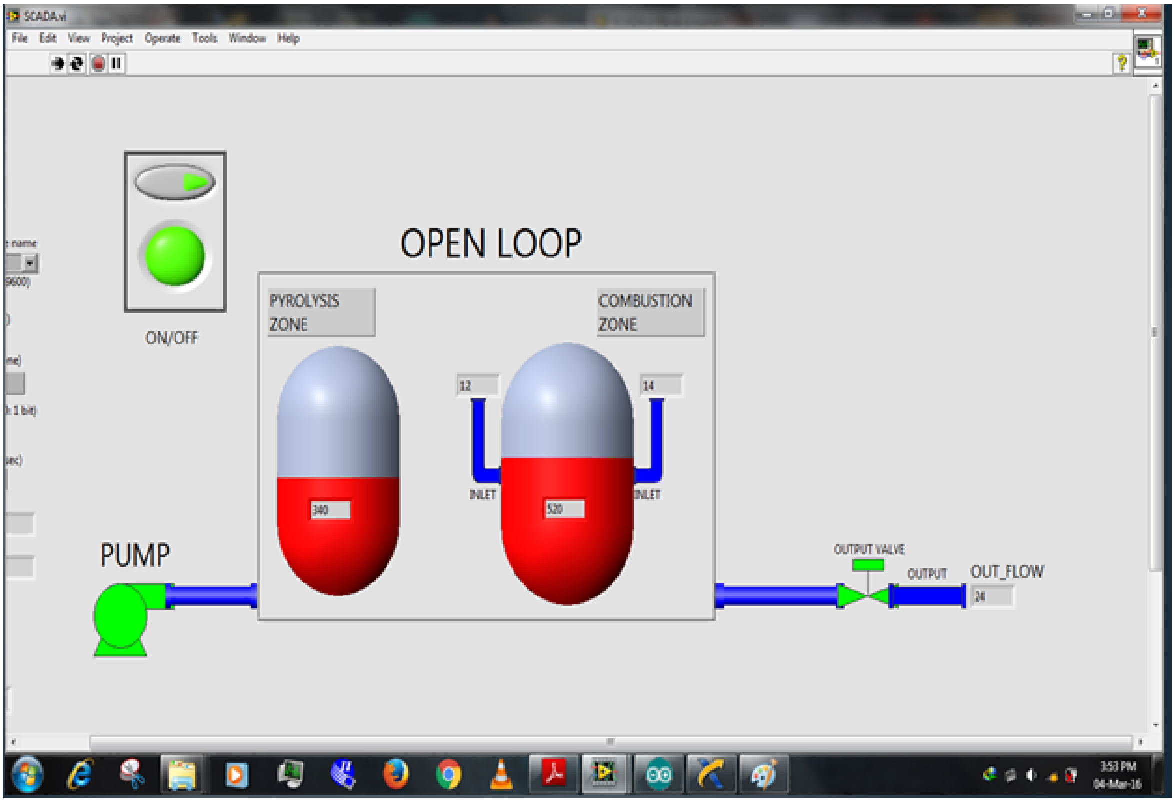

Figure 4.11: SCADA in LabVIEW

Temperature of the combustion zone and pyrolysis zone is measured. The inlet flow of the biomass gasifier is 24 m3/h.

Chapter 5

System Identification

System identification of a biomass gasifier has done using the system identification tool in MATLAB.

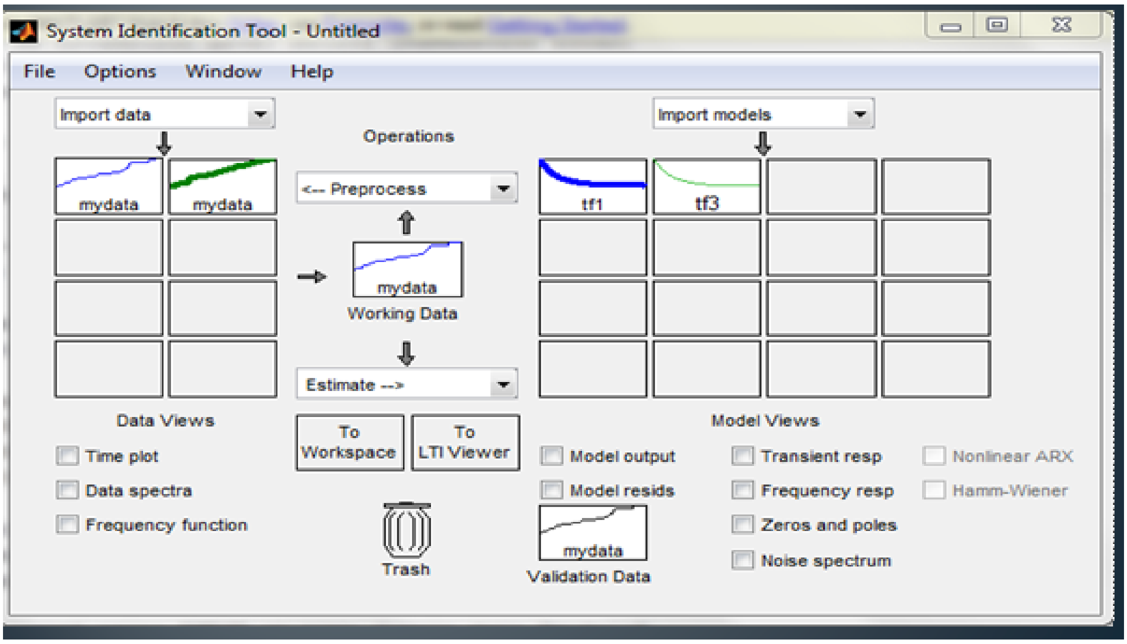

Figure 5.1: System identification tool

To using this tool, transfer function, process model, nonlinear model, state space model, polynomial model, correlation model can be estimated.

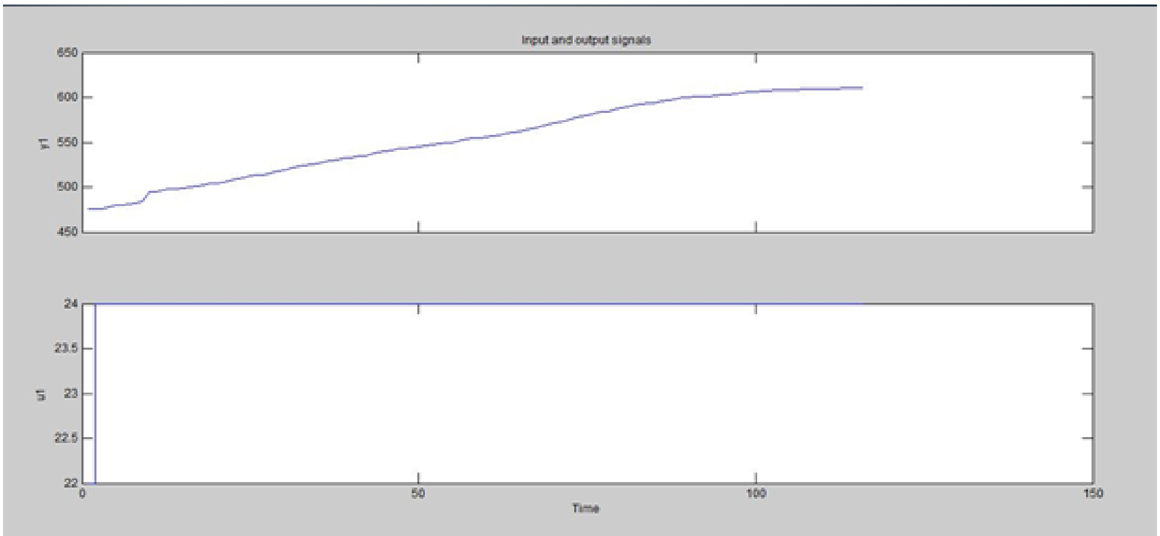

Figure 5.2: Input Output signall

First import the data from the workspace which is in matrix from. And then click on the estimate button.

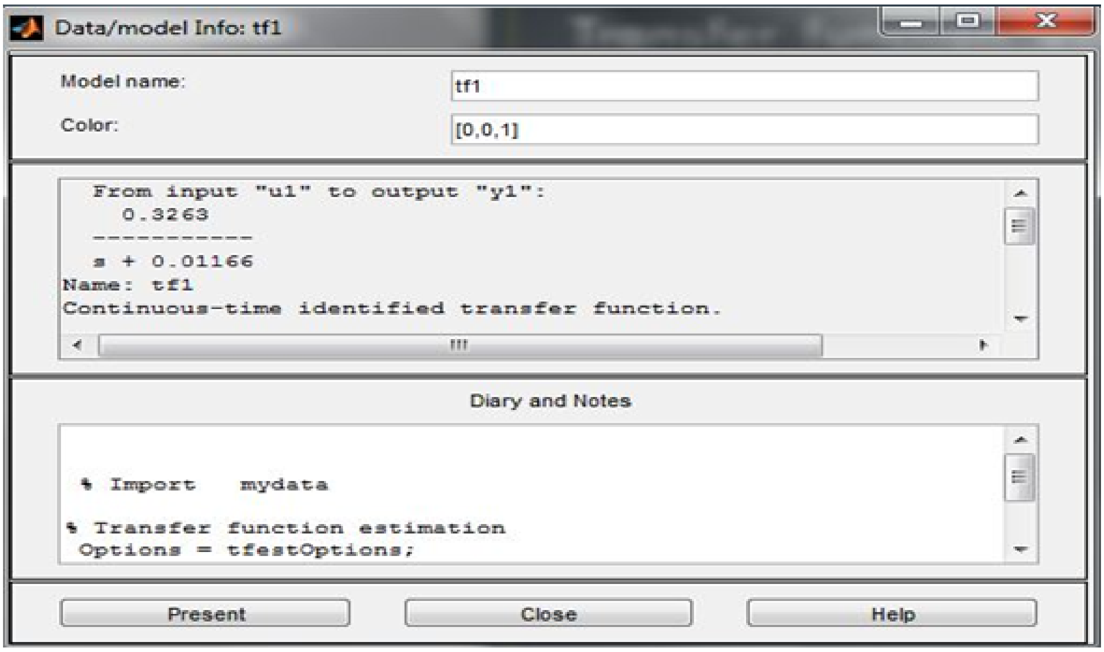

Figure 5.3: Transfer function

Transfer function gives a dynamic behavior of a system. And it is used to design a controller. The behavior o of a gasifier is,

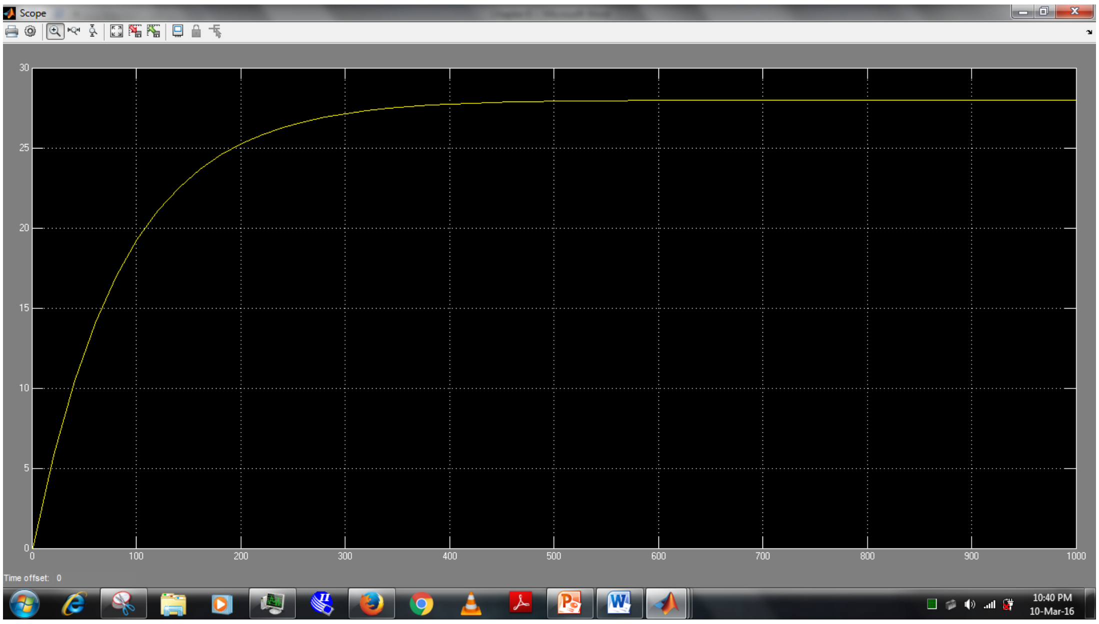

Figure 5.4: Dynamic behaviour of the Biomass Gasifier

The gain of the transfer function is K=28 and the =85.3 sec. so for the tuning of the PID controller Ziegler Necholos mathod is used.

5.1 PID Tuning

Ziegler - Nichols method is a standard mathod for PID tuning. The given steps have to be followed. 1) Carry the system to a steady state condition . 2) Put the proposnal gain and vary till the ocillation is stady state. 3) Time taken to reach a steady state ocillation condition is called Pu(ultimate ocillation) and the gain is called Ku(ultimate gain). Using these steps, the PID tunig table is given bellow.

controller	K_c	T_i	T_D
P	14	-	-
PI	12.72	2.5	-
PID	16.47	1.7	0.375

Figure 5.5: PID tuning

For different controller, different response of the system is simulated using MATLAB Simulink.

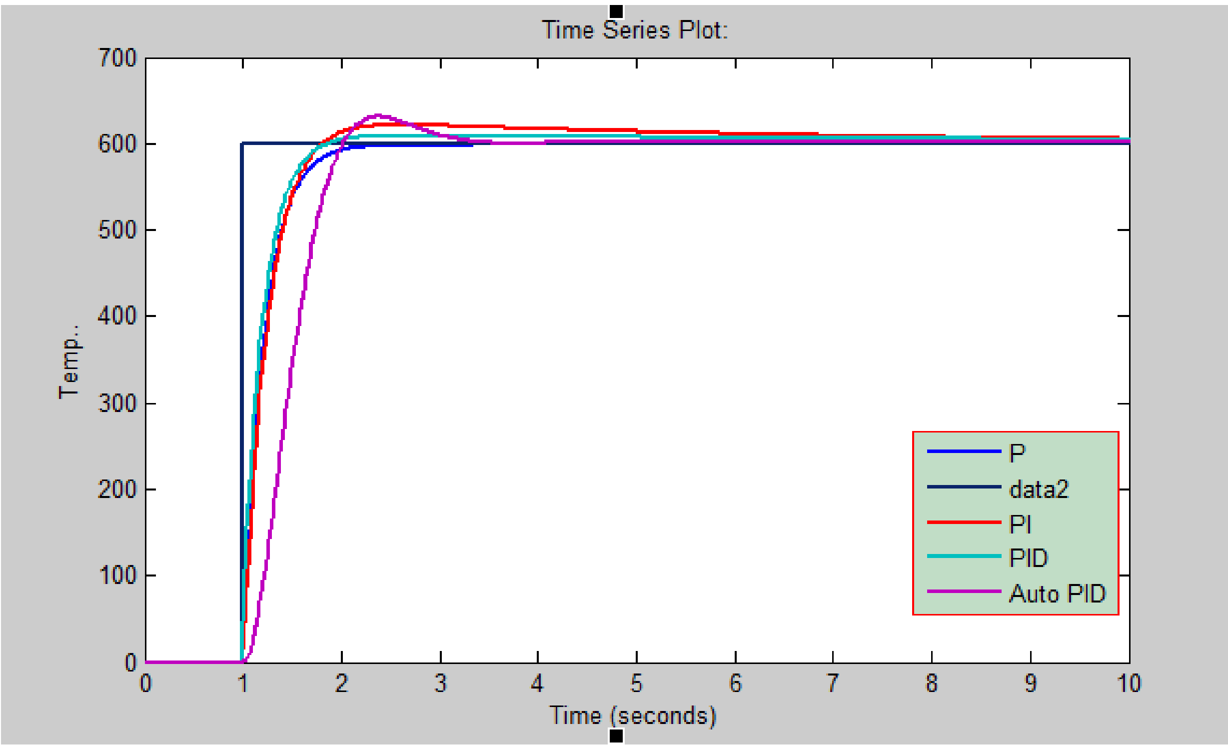

Figure 5.6: Simulation with different mode of control

Different control mode is applied and output is simulation using Matlab Simulink. It can be observed that, P mode will take less time to reach the steady state condition but there is permanent error. PI mode, there is a overshoot but set point is achieved after 20 sec. In PID mode, there is a less overshoot but it will take 30 sec to get the set point.

It can be observed that, PI mode is batter choice among all to control the Temperature of the gasification process.

5.2 GUI (Graphical User Interface)

GUI (Graphical user interface) is single window which has many control options. GUI is developed based on the thermodynamic equilibrium model. Effect of moisture content on syngas composition is estimated at constant temperature and equivalence ratio.

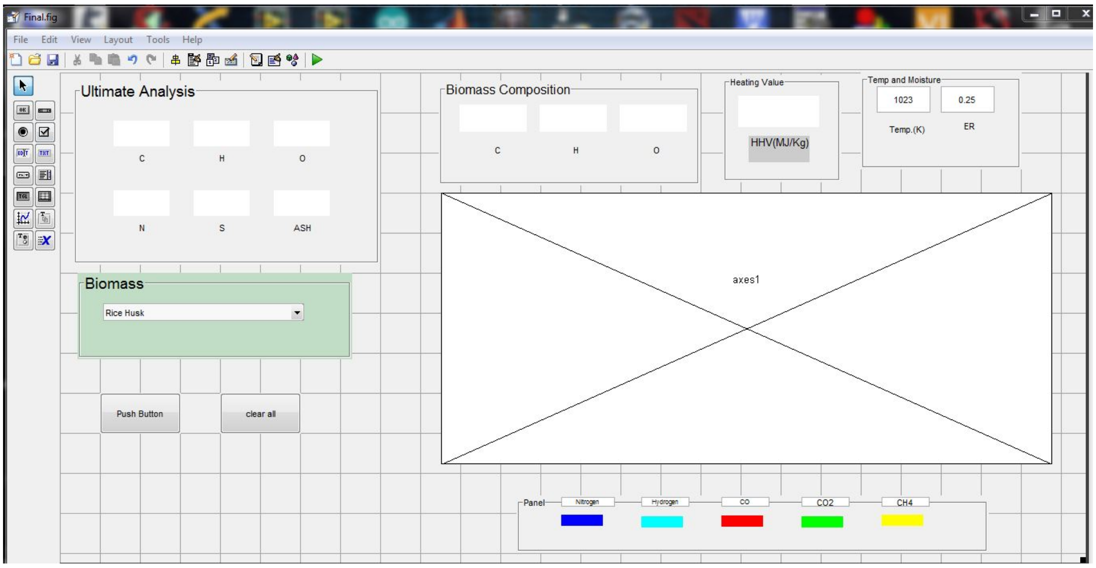

Figure 5.7: GUI for different biomass materials

Biomass composition, higher heating value and molar fraction vs. moisture content graph estimated. Temperature (1023 K) and ER (0.25) of the gasifier is a constant because the value of the CV (Calorific Value) is decreases with the temperature and temperature is vary with the ER Ratio.

In India, many villages are still not connected with electricity via cable so biomass gasifier can be used there to generate the electricity. Large amount of biomass mass is easily available. Bamboo is widely available and fast growing tree in north east India. Gulmohor is a read side tree in Gujarat, UP, Maharashtra, and Punjab state. Neem is available all over India. Dimaru, Rice husk is a mainly available in south Indian states and also In Punjab. Shisham is available in MP and Bihar. In This GUI simulation is done for this biomass which is based on the thermodynamic equilibrium model.

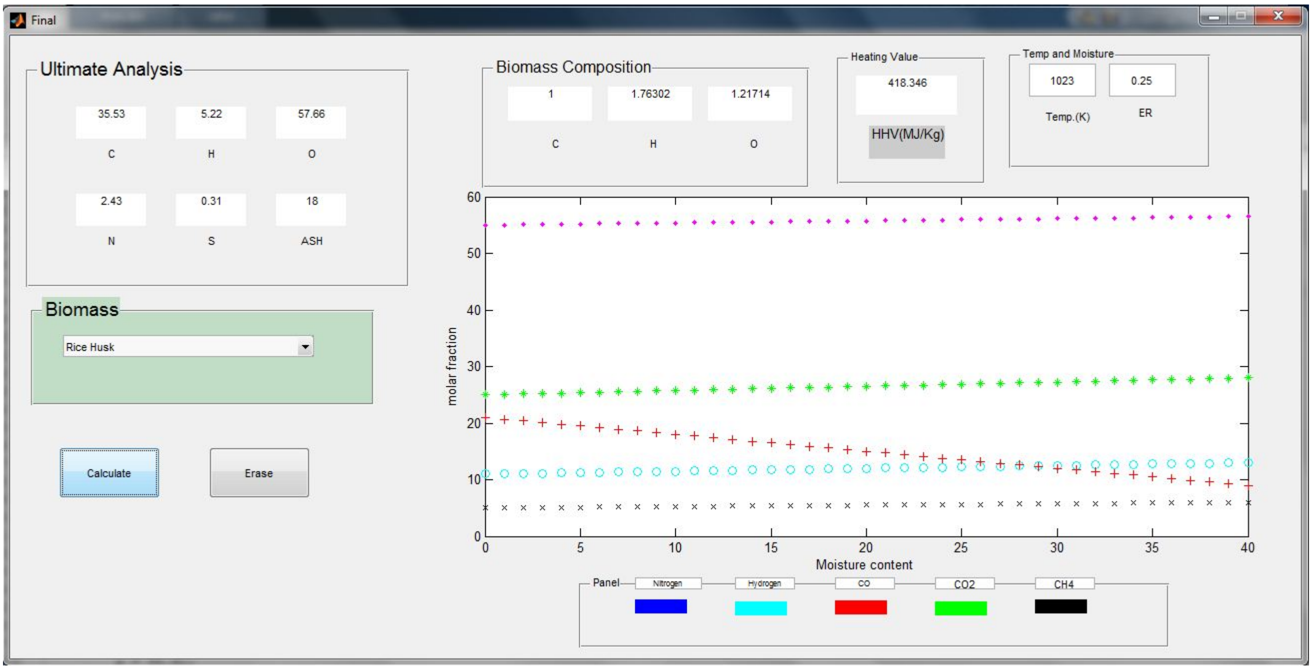

Figure 5.8: Molar Fraction for Rice Husk

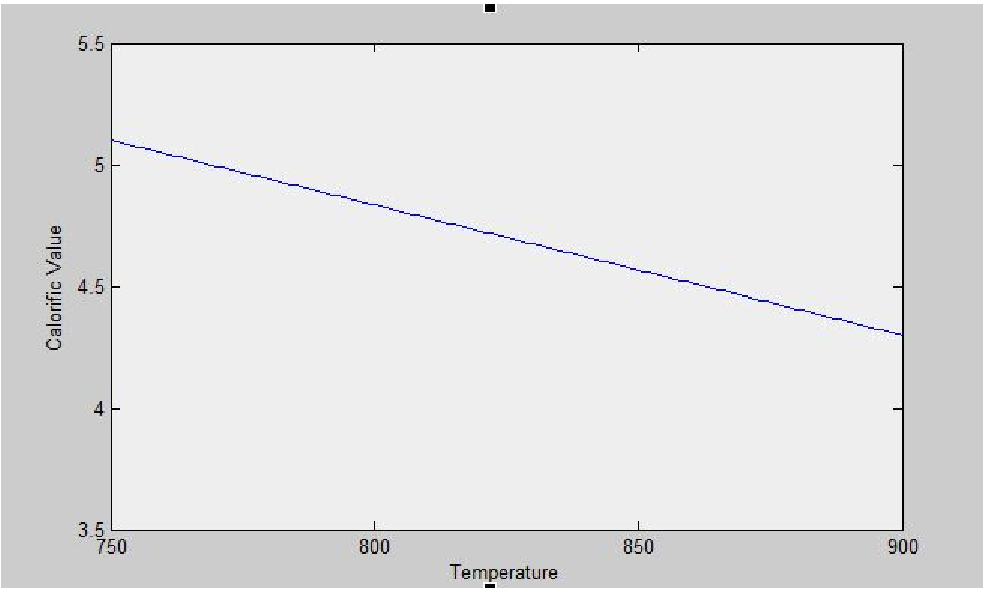

Figure 5.9: Fig. Calorific Value vs. Temperature

Calorific value of the any biomass is decreases when the temperature is increases.

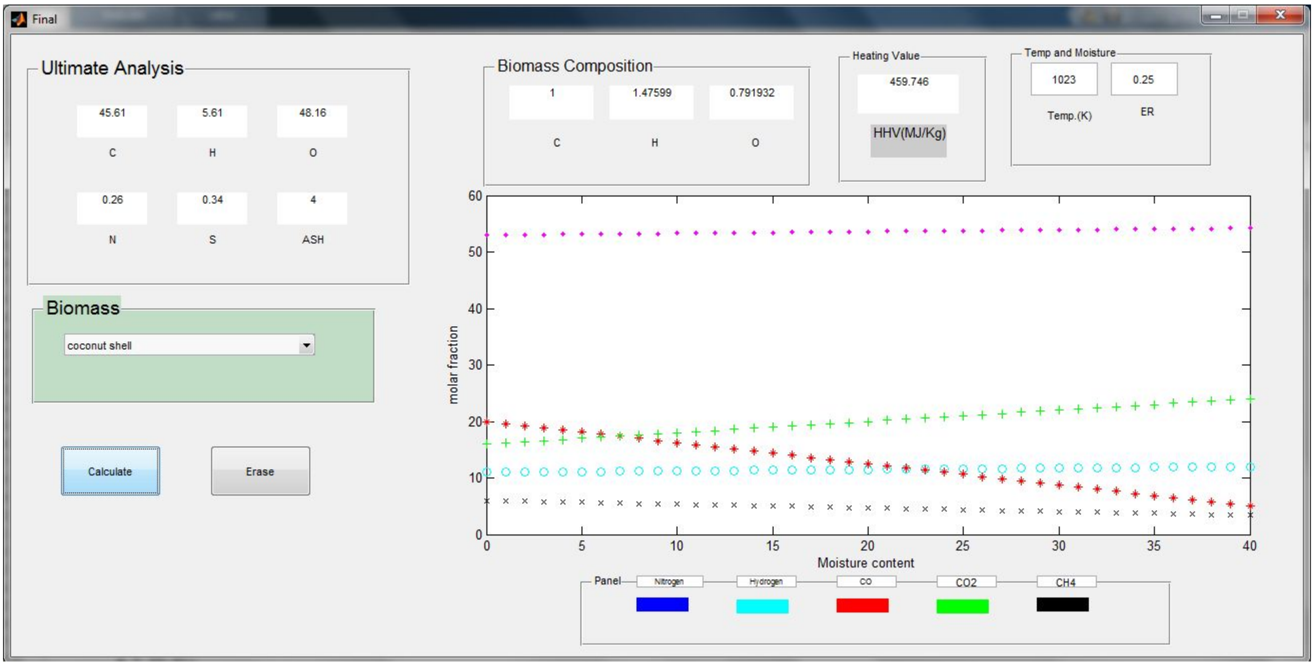

Figure 5.10: Molar Fraction for Coconut shell

5.3 Results and Discussion

After simulation of different biomass using thermodynamic model of zinal, at 1023K temp And 0.25 ER, it can be observed that the value of H_2 and CO is decreases when the amount of moisture is increasing. N_2 is inter, not a large amount of the changes is accrues with the moisture content. CO_2 and CH4 are increases with a moister content.

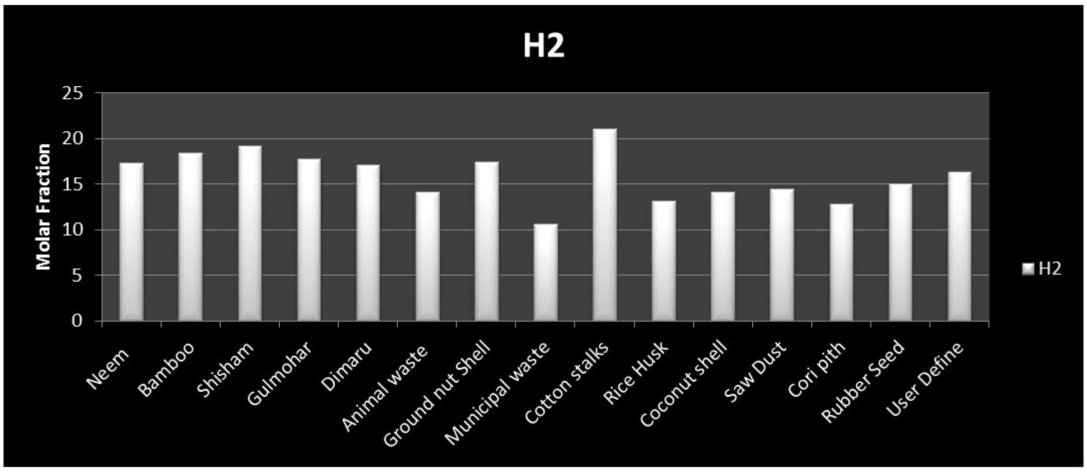

Figure 5.11: Molar fraction of Hydrogen

Molar fraction of H_2 is more in the cotton stalks and Shisham. While in animal waste and Municipal waste H_2 is low.

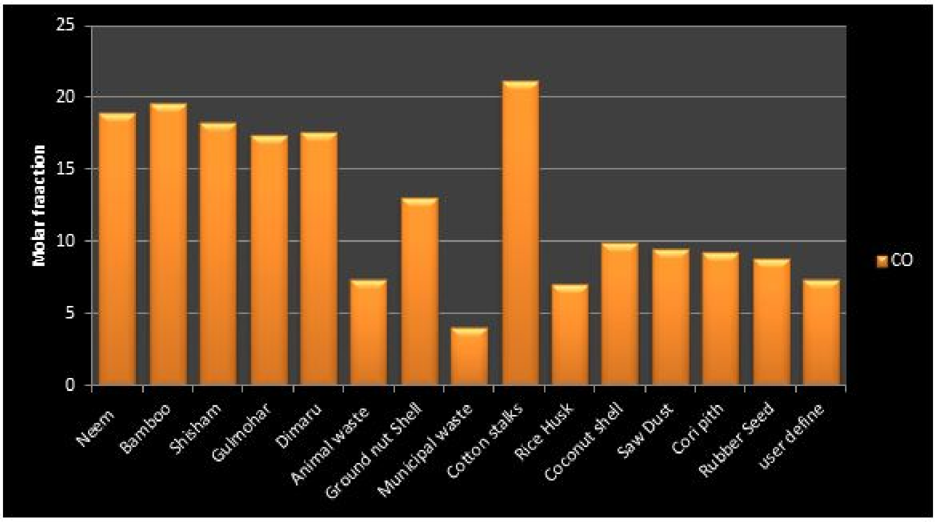

Figure 5.12: Molar fraction of Carbon monoxide

Molar Fraction of the carbon monoxide is more in cotton stalks.

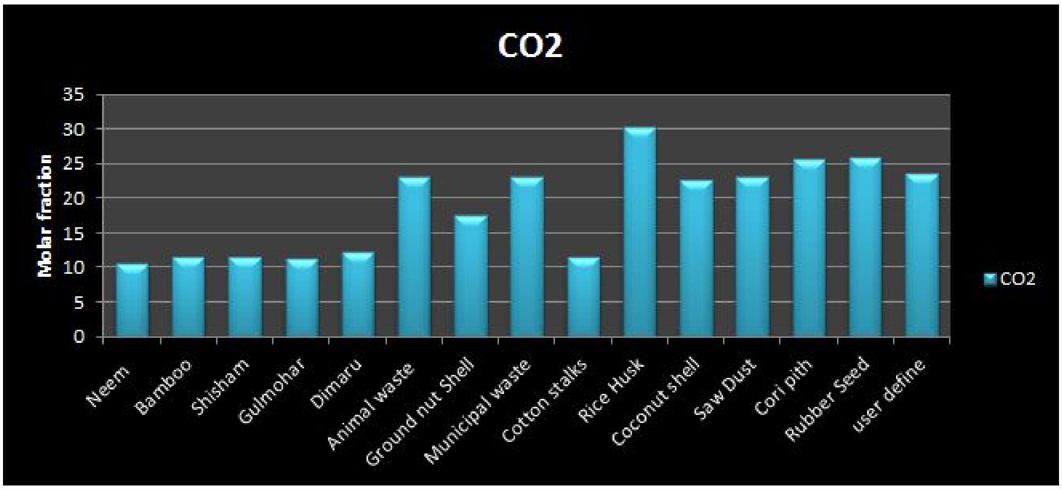

Figure 5.13: Molar fraction of Carbon dioxide

The amount of the CO_2 is more in the rice husk and lowest in the cotton stalks.

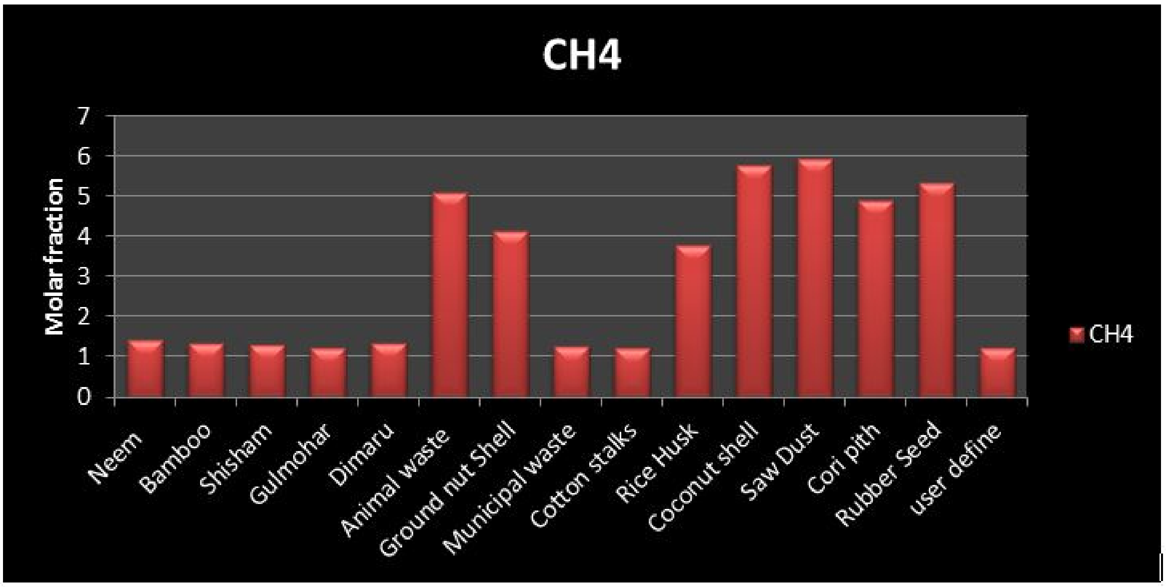

Figure 5.14: Molar fraction of methane

Amount of the CH_4 is more in the animal waste and lowest in the municipal waste.

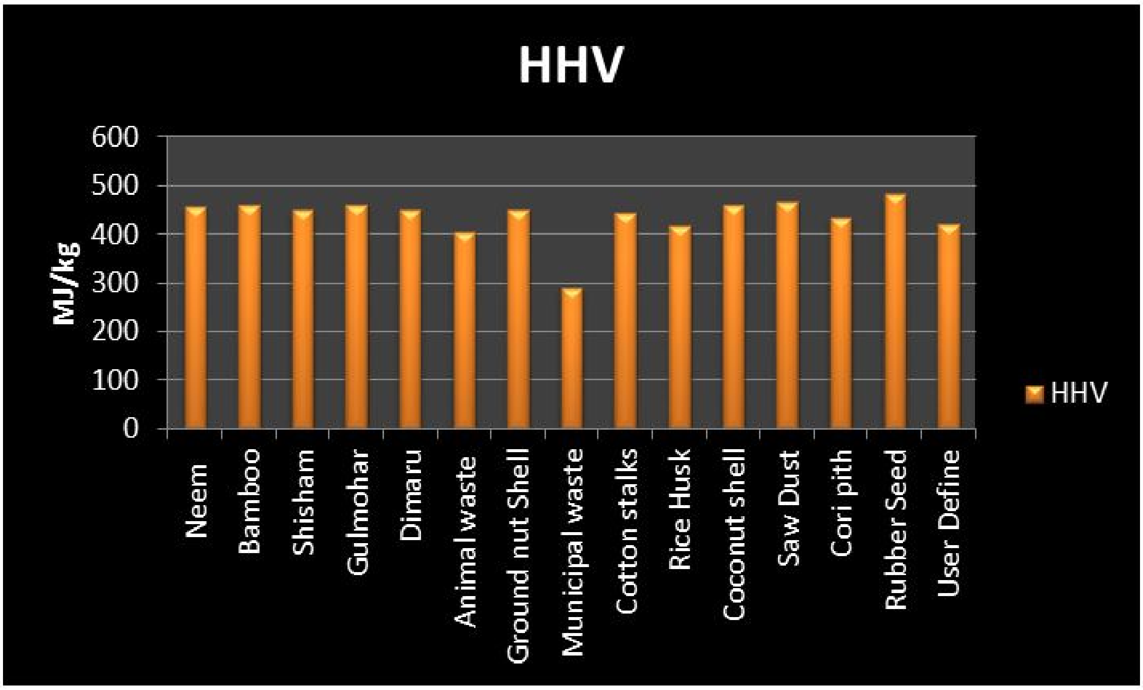

Figure 5.15: Higher Heating Value of Diffrent Biomass

Chapter 6

Conclusion and Future Scope

6.1 Conclusion

1) Thermodynamic equilibrium model has been simulated using Matlab platform to study different parametric study for different biomass. GUI is built for the widely available biomass in INDIA so that it will helpful for the energy production in a remote area.
2) Static Model is estimated for controller design for large scale biomass gasifier which is used for electricity generation.
3) DAQ (Data Acquisition System) is implimented using Arduino (Microcontroller) and K type thermocouple.
4) Dyanamic model is estimated using system identification tool in Matlab.
5) Conventional Controller is design and close loop study has been done.

6.2 Future Scope

1) Development of SCADA for existing gasifier system.
2) Implementation of advance control algorithm to predict the producer gas composition.
3) For more accurate result, nitrogen and sulfur (N, S) has to be added in the thermodynamic model (C Ha Ob Nc Sd).

4) Use steam and air flow mixture as oxidizer and predict performance parameters.

References

[1] Zainal ZA, Ali R, Lean CH, Seetharamu KN. Prediction of performance of a Downdraft gasifier using equilibrium modeling for different biomass Materials Energy Convers Manage 2001;42:1499515.

2] Marcelo Echegaray, Rosa Rodriguez, Maria Rosa Castro. Equilibrium model Of the gasification process of agro-Industrial wastes for energy productionInternational Journal of Engineering Science Innovative Technology (IJESIT)

[3] P.P Dattu, V.pandey, A.R. Das, S. sen, D. C. Baruah Down Draft Gasifier Modelling and Experimentation of some Indigeous Biomass for Thermal Application Energy procedia 54(2014) 21-34

[4] c.sagues, P Garcia-Bacaioa, S. Serrano Automatic control of biomass gasifier Using fuzzy inference system Bio resource Technology 98(2007)

[5] Samson M. Atnaw, Suzana Yusup Prediction of Calorific Value of Syngas Produced from Oil-Palm Fronds Gasification Department of Mechanical Engineering, Universiti Teknologi PETRONAS Tronoh, Perak, Malaysia

[6] Samson Mekbib Atnaw, Shahrin Anwar Sulaniman Modeling and Simulation Of Downdraft Gasifier Using Oil-Palm Fronds Proceedings of ICEE 2009 3rd International Conference on Energy and Environment,7-8 December 2009, Malacca, Malaysia

[7] jayah TH, Aye L, Fuller RJ, Stewaet DF Computer simulation of a downdraft wood Gasification for tea drying Biomass bioenergy 2003;25:4596

[8] Avdhesh Kr. Sharma Influence of Biomass Materials and Gas Flow Rate on Downdraft Gasifier Performance Dept. of Mechanical Engineering D.C.R. University of Science Technology, Murthal Sonepat, India

[9] Rantnagiya J.K , Channiwala S.A. Three zone equilibrium abd Kinetic free modeling of biomass gasifier a novel approach . Renewable Energy 200.

[10]Andre Melger, Juan F. Perez, Hannes Laget, Alfonso Horillo. Thermochemical equilibrium modeling of a gasifying process Energy Conversion and Management, 2006

[11]Altafini R. Carlos, Wander R. Paulo, Barroto M. Ronaldo. Prediction of the

working parameter of a wood waste gasifier through an equilibrium model Energy conversion and Management 44(2003)

[12] Baratieri M. Baggio P, Fiori L, M.Grigiante. Biomass as an energy source: Thermodynamic constraints on the performance of the conversion process bio resource Technology, 2007

[13] Modeling and simulation of a downdraft biomass gasifier 1. Model development and validation Energy Conversion and Management 52 (2011) 13861396

[14] A.Z. Mendiburu et al Thermochemical equilibrium modeling of biomass downdraft gasifier: Stoichiometric models Energy 66 (2014) 189e201

[15] S. Jarungthammachote, A. Dutta Thermodynamic equilibrium model and second law analysis of a downdraft waste gasifier Energy 32 (2007) 16601669

[16] Samson M. Atnaw, Suzana Yusup Prediction of Calorific Value of Syngas Produced from Oil-Palm Fronds Gasification Department of Mechanical Engineering, Universiti Teknologi PETRONAS Tronoh, Perak, Malaysia

[17] Mohamed Ali Masmoudi Numerical modeling of combined partial oxidation and gasification zones in a downdraft gasifier fueled by almond shell The fifth International Renewable Energy Congress IREC 2014

[18] http://www.intechopen.com/books/gasification

[19] Sharma AK. Equilibrium kinetic modeling of reduction reactions in the char bed of a downdraft (biomass) gasifier a comparison. Int J Solar Energy 2008;82:91828.

[20] Babu BV, Sheth PN Modeling and simulation of reduction zone of downdraft biomass gasifier: effect of char reactivity factor Energy Convers Manage 2006;47(15-16):260211.

[21] Gao N, Li A. Modelling and simulation of combined pyrolysis and reduction zone for a downdraft biomass gasifier. Energy Convers Manage 2008;49:348390.

[22] Samson Mekbib Atnaw Modeling and Simulation Study of Downdraft Gasifier Using Oil-Palm Fronds. 978-1-4244-5145-6/09/2009 IEEE

[23]Alauddin ZA.performance and characteristics of a biomass gasifier system. PhD thesis, university of wales collage of Cardiff,uk, 1996

[24] http://teriin.org/technology/biomass-gasifier.php (Accessed on 12 april 2016)

[25] http://cturare.tripod.com/pro.htm (Accessed on 19 april 2016)

[26] http://www.scielo.org.co/scielo.ph(Accessed on 1 May 2016)

[27]Darshit S. Upadhyay. Performance Evaluation of Lignite in a Downdraft Gasifier M.tech dissertation, Department of Mechanical Engineering. Institute of technology. Nirma University, Ahmedabad.

[28]Dr. Jayesh Barve and Smit Rajpura, Model based operational study of Downdraft biomass gasifier, National Conference of Plant Plysiology 2013 on Current Trends in Plant Biology Research,2013.

Chapter 7

ABBREVIATION

1 CV-Calorific Value

2 DST-Department of Science and Technology

3 DAQ-Data Acquisition System

4 ER-Equivalence Ratio

5 FC-Fuel consumption

6 Fg -Frequency of Grate

7 Fr-Air Flow rate

8 GUI-Graphical User Interface

9 Hm-Moisture Content

10 LabVIEW- Laboratory Virtual Instrument Engineering Workbench

10 Mc- Material Composition

11 Matlab-Mathematical laboratory

12 HHV-Higher Heating Value

13 SCADA-Supervisory Control and Data Acquisition

Publication

1. Nihal Dalwadi, Prof. Alpesh Patel and Prof Darshit Upadhyay ”Study and Analysis of Biomass Gasifiers Models”, International Conference on Innovative Advancements in Engineering and Technology (IAET) 2016