

EVALUATION OF BIO AND ORGANIC WASTE FOR BIOHYDROGEN PRODUCTION USING FUZZY LOGIC TECHNIQUE

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Technology degree in
Chemical Engineering
by

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**DEPARTMENT OF CHEMICAL ENGINEERING
SCHOOL OF BIO AND CHEMICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAR NAGAR, RAJIV GANDHI SALAI, CHENNAI-600 119

APRIL 2021



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **GOVARTHINI S (37190021)**, **ANNA DOMINIC (37190011)** who carried out the project entitled **"EVALUATION OF BIO AND ORGANIC WASTE FOR BIOHYDROGEN PRODUCTION USING FUZZY LOGIC TECHNIQUE"** under my supervision from February, 2020 to April, 2021.

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Submitted for Viva voce Examination held on _____

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DECLARATION

I, **GOVARTHINI S (37190021)** hereby declare that the Project Report entitled **“EVALUATION OF BIO AND ORGANIC WASTE FOR BIOHYDROGEN PRODUCTION USING FUZZY LOGIC TECHNIQUE”** done by me under the guidance of **Dr. S. SATHISH, M.E., Ph. D.** and **Dr. S S DAWN M.Tech.,Ph.D.**, at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Chemical Engineering.

DATE: 18.03.2021

PLACE: Chennai



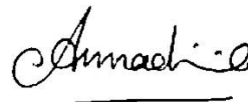
SIGNATURE OF THE CANDIDATE

DECLARATION

I, **ANNA DOMINIC (37190011)** hereby declare that the Project Report entitled **“EVALUATION OF BIO AND ORGANIC WASTE FOR BIOHYDROGEN PRODUCTION USING FUZZY LOGIC TECHNIQUE”** done by me under the guidance of **Dr. S.SATHISH, M.E., Ph.D.** and **Dr. S S DAWN M.Tech., Ph.D.**, at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Chemical Engineering.

DATE: 18.03.2021

PLACE: Chennai

A handwritten signature in black ink, appearing to read 'Anna Dominic', written over a horizontal line.

SIGNATURE OF THE CANDIDATE

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ABSTRACT

Biohydrogen is the clean, renewable and the best replacement for fossil fuel. Although biohydrogen production is not implemented in pilot scale the research has been done by various method for increasing the biohydrogen production. Uses of fossil fuel is the cause of greenhouse gas emission, global warming etc., To avoid this biohydrogen production has become solution. Using Bio and organic waste as the feed stock in anaerobic fermentation for hydrogen production is an ecological friendly approach instead of following land filling and incineration methods for waste management. Among various method of biohydrogen production like light fermentation, photolysis etc., anaerobic fermentation has a advantage that it is independent of light. From literature survey, hydrogen yield is higher in anaerobic condition. In this project the prediction has to be done using fuzzy logic tool in MATLAB for optimizing the parameters for obtaining higher hydrogen yield. Data has been obtained in literature survey. Using that data prediction is done. Fuzzy logic is prediction tool in MATLAB this works on Adaptive Neuro Fuzzy Inference system. Experiment should be done in both the controller and validate the value.

Keywords: biohydrogen, fuzzy logic, ANFIS, carbohydrate, dark fermentation.

TABLE OF CONTENTS

CHAPTER No.	TITLE	PAGE No.
	ABSTRACT	iv
	LISTS OF TABLES	x
	LISTS OF FIGURES	ix
1	INTRODUCTION	1
	1.1 BIOHYDROGEN	1
	1.1.1 CARBOHYDRATES	2
	1.1.2 PROTEIN	2
	1.2 COMMERICAL METHOD OF PRODUCTION	3
	1.2.1 HYDRO CARBON REFORMING	3
	1.2.2 HYDRO CARBON PYROLYSIS	4
	1.3 BIOHYDROGEN PRODUCTION METHOD	5
	1.4 FUZZY LOGIC TECHNIQUE	9
2	LITERATURE SURVEY	11
3	AIM AND SCOPE	22
4	PERFORMANCE ANALYSIS	23
	4.1 MATERIAL BALANCE	26
	4.2 ENERGY BALANCE	28
5	METHOD AND ALGORITHM	29
	5.1 FUZZY LOGIC	29
	5.1.1 MAMDANI CONTROLLER	29
	5.1.2 SUGINO CONTROLLER	33
	5.1.2 A ADAPTIVE NEURO FUZZY INFERENCE	35
	5.1.3 VALIDATION	
	5.1.4 RESULT	43

6	SUMMARY AND CONCLUSION	45
	REFERENCES	46

LISTS OF FIGURES

FIGURE NO.	FIGURES	PAGE NO.
1.4.1	Biohydrogen production flowsheet	5
1.4.2	Direct photolysis	6
1.4.3	Indirect photolysis	7
1.4.4	Photofermentation	8
1.4.5	Fuzzy logic technique	9
4.1	Block flow diagram	23
4.2	Process flow diagram	24
5.1.1	Variables 1	31
5.1.2	Inference system	32
5.1.3	Member function 1	33
5.1.4	Rule table 1	34
5.1.5	Result 1	34
5.2.1	Command screen 2	35
5.2.2	Work space 2	36
5.2.3	Variables 2	36
5.2.4	Member function 2	37
5.2.5	Training data	37
5.2.6	Trained value	38
5.2.7	Adaptive neural network 2	39
5.2.8	Result 2	40
5.2.9	Surface image	41

LISTS OF TABLES

TABLE No.	TITLE	PAGE No.
2.1	Operating conditions and volume	11
2.2	Substrate characteristics	12
2.3.1	Proximate analysis	17
2.3.2	Proximate analysis	18
2.3.3	Proximate analysis	19
2.3.4	Proximate analysis	20
2.3.5	Proximate analysis	21
4.3.1	Data for stoichiometry	27
5.1	Rule table	33

CHAPTER-1

INTRODUCTION

1.1 BIOHYDROGEN

Hydrogen is a typical reactant in Petro-chemical industry and it is best alternative for fossil fuel because the byproduct of hydrogen combustion is water. Ecological pollution caused by use of fossil fuel will be avoided by hydrogen. Use of fossil fuel can produce a greenhouse gas which is the reason for the ozone layer depletion. Combustion of fossil fuel is the threat for the environment. Currently worldwide energy request depends on the fossil fuel which causes serious environmental pollution from by-product. The researchers has accepted the fact that increasing carbon di oxide in atmosphere is due the use of fossil fuel, impacting on global warming and greenhouse gas effect.

The best replacement for fossil fuel is hydrogen because of its clean, renewable and ecofriendly nature. Hydrogen is generally made by physio-chemical method that parts fossil fuel that accounts for 30% from oil, 48% from natural gases, 18% coal. Hydrogen gas is known for its extraordinary efficient power energy potential, it has acquired extensive research interest. hydrogen is likewise be helpful in controlling global warming and in increasing ecological pollution problem, furthermore it is preferred over possessing to its more extensive modern application. however commercial methods of hydrogen production is done by polluting the environment. It is important to utilize other sources and technique to get hydrogen. Biohydrogen is created from biomass through thermochemical or organic cycles .it can be in the fluid or gaseous state. Owing to its environmental benefits and lower energy necessities biological methods are preferred than thermochemical process.

Biohydrogen production has a few great properties, for example lower operational expenses, simplicity of control and waste remediation. Among different hydrogen production technique, biohydrogen production is most possible proficient strategy with benefit of changing over organic waste at ambient pressure and temperature.

Biohydrogen production from an organic waste is a best method to manage organic waste with very low environmental contamination because they contain organic compounds such as polysaccharide and protein.

1.1.1 CARBOHYDRATE

Food waste that are rich in carbohydrate is an feedstock for hydrogen production from dark fermentation. Although hydrogen production will be higher in substrate with higher carbohydrate content, it is only applicable for easily biodegradable compounds such as starch and simple sugars which will be turned into the hydrogen on anaerobic digestion through acetate and butyrate pathways. Carbohydrate content of the feedstock found to have major influence in hydrogen production. Among various composition of substrate for dark fermentation, carbohydrate-rich substrate found to have maximum hydrogen yield. Starch and cellulosic rich materials, such as vegetable, fruit peels, roots, etc., For Cellulosic substance like lignin, cellulose and hemicellulose (vegetable peel, fruit peel, roots etc.) the molecules need to be broken down to either monosaccharides or polysaccharide through hydrolysis before dark fermentation. studies found the effect of variety of carbohydrate on dark fermentation and concluded that cellulose has lower efficiency in hydrogen production, compared to sucrose and glucose. Carbohydrate content in rice, potato and cereal waste has higher hydrogen production.

1.1.2 PROTEIN

Nitrogen source in food waste is protein which is responsible for the stimulation of microorganism function and plays important role in increasing the efficiency of gas production from food waste. The fluctuation of pH due to high microorganism activity during fermentation is stabilized by nitrogen in protein molecules. Despite the important function of protein molecules, protein itself causes the difficulties in degradation because of its structure and thus protein content could be a rate limiting factor for lowering the efficiency in hydrogen production. Various studies were carried out for digestion of protein to small molecules for increasing the efficiency of hydrogen production from protein rich substrate. Research concluded that efficiency of hydrogen production from

protein rich content can be increased by adding pre-treatment step for digestion of protein into small amino acid before dark fermentation.

1.2 COMMERCIAL METHOD OF HYDROGEN PRODUCTION

From Fossil fuel

- Hydrocarbon pyrolysis
- Hydrocarbon reforming
 - I. Partial oxidation
 - II. Autothermal reforming
 - III. Steam Reforming

1.2.1 HYDROCARBON REFORMING

The conversion of hydrocarbon fuel into hydrogen using reforming techniques is hydrocarbon reforming. The reforming plants contains desulphurization unit, reforming, clean up section auxiliary units like compressor, heat exchanger, pumps expander and cooler.

STEAM REFORMING

Catalytic conversion of steam and hydrocarbon to carbon oxides and hydrogen is steam reforming. The steps involved in this process are synthesis or reforming gas generation, gas purification or methanation, water-gas shift. Natural gas, Methane and gases with methane of various combination of hydrocarbons including heavy naphtha, light naphtha, pentane, propane, butane, ethane. The presence of organic Sulphur in the feedstock will make the reforming step preceded by desulphurization to stop the catalytic poison. The catalyst used will be based on nickel. To produce pure hydrogen product and to avoid coking forming the reaction parameters are kept at high temperature and pressure.

METHANE AND STEAM REFORMING:



WATER GAS SHIFT:



PARTIAL OXIDATION

This method involves conversion of oxygen, hydrocarbon and steam to carbon oxides and hydrogen. At 950°C catalytic process occurs with feedstock from methane to naphtha. At 1150–1315 °C non-catalytic process occurs with feedstock like heavy oil, methane and coal. Partial oxidation of hydrocarbon feedstock and syngas produced treated further using pure oxygen after removal of sulfur. Partial oxidation is the most suitable technology for producing hydrogen from coal and heavy oil residues. The equation of methanation and water shift gas is given as:

PARTIAL OXIDATION OF METHANE



WATER GAS SHIFT REACTION



AUTOTHERMAL REFORMING METHOD

This method produces heat by using partial oxidation exothermically and steam reforming endothermically to increase the hydrogen production. The injection of oxygen and steam makes reformer to perform oxidation reaction and reforming reaction simultaneously.

1.2.2 HYDROCARBON PYROLYSIS

Here the source of hydrocarbon is hydrogen that undergoes thermal decomposition.

The production of hydrogen is done in two steps

1. Hydro gasification
2. Cracking of methane

1.3 BIOHYDROGEN PRODUCTION METHOD

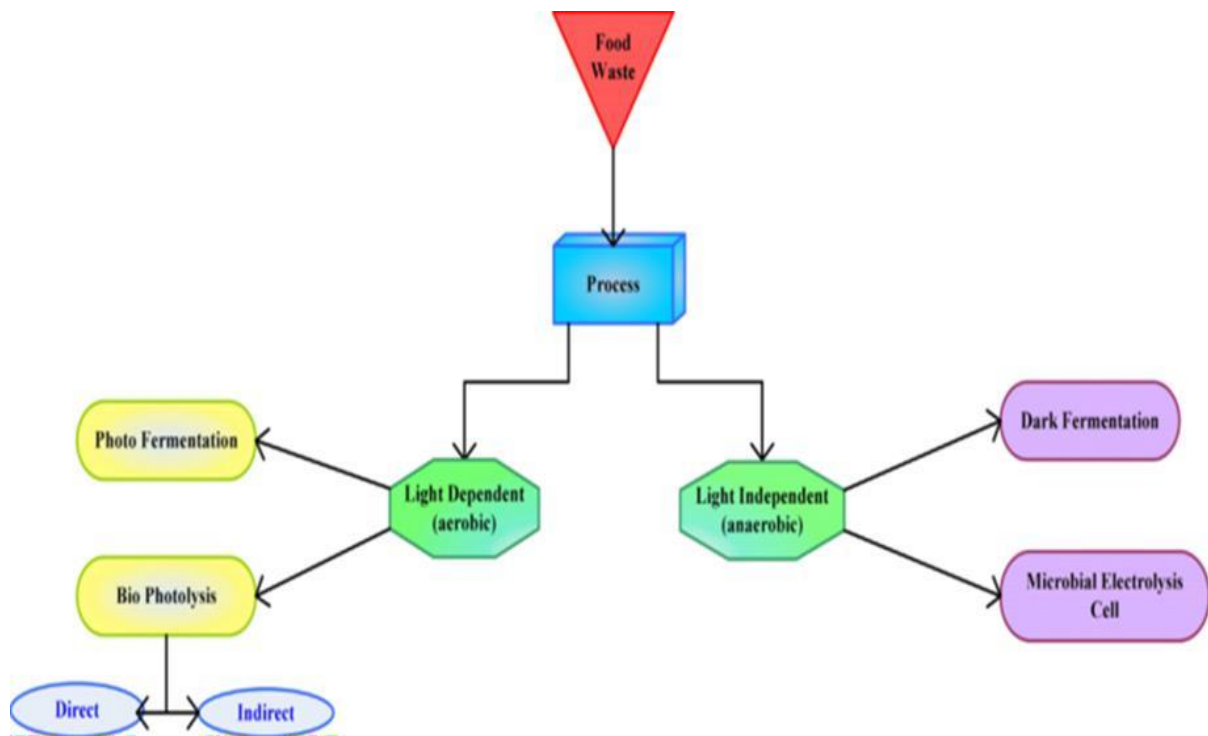


Figure 1.3.1: Biohydrogen Production Method

Biohydrogen production process divided into:

1. Light dependent (aerobic)
 - I. Photo fermentation
 - II. Bio photolysis
 - Direct
 - Indirect
2. Light independent (Anaerobic)
 - Dark fermentation
 - Microbial electrolysis cell

The biological process that are mostly used for hydrogen production are indirect bio photolysis, direct bio photolysis, dark fermentation, photo fermentation, multistage photo fermentation and multistage dark fermentation.

BIO PHOTOLYSIS

Biological hydrogen production by bio photolysis are sustainable and ecological friendly way for the production of clean energy from renewable resources. The separation of water molecules by green microalgae and cyanobacteria is Bio photolysis.

DIRECT PHOTOLYSIS

The utilization of cyanobacteria for the production of hydrogen through step of reaction is direct bio photolysis. It is the overall reaction in two photosystem that are used in plant photosynthesis.

When the reaction is happening water, splitting happens by photons absorption that reduces ferredoxin that is used hydrogen production through reduction of protons. This process of splitting water into oxygen and hydrogen will include both hydrogenase and nitrogenase enzyme system.

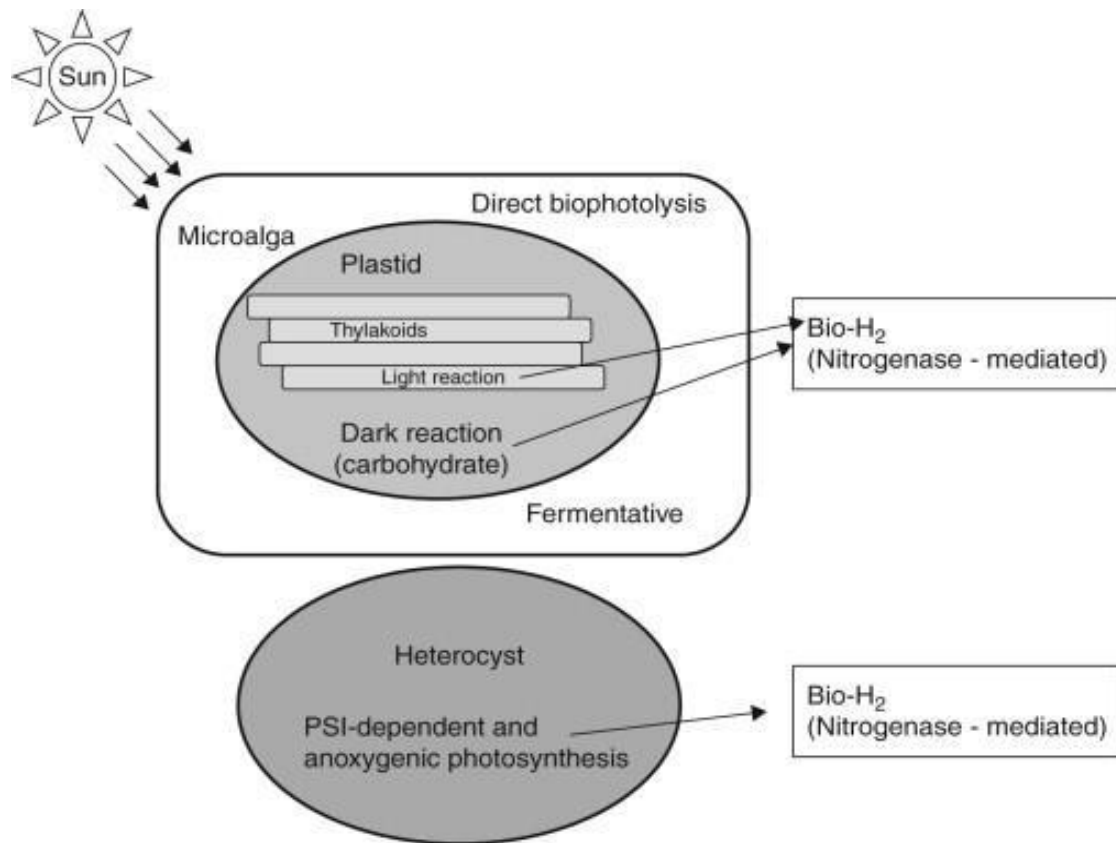


Figure 1.3.2: Direct Photolysis

INDIRECT BIO PHOTOLYSIS

In this process hydrogen is produced from water through the cyanobacteria and microalgae. The conversion of solar energy into chemical energy is carried out by photosynthetic system. Here bio photolysis happens in two steps, first the photosynthetic system produces large amount of biomass that results in increased carbohydrate in biomass. secondly, carbohydrate rich biomass that are stored is used for hydrogen production through fermentation.



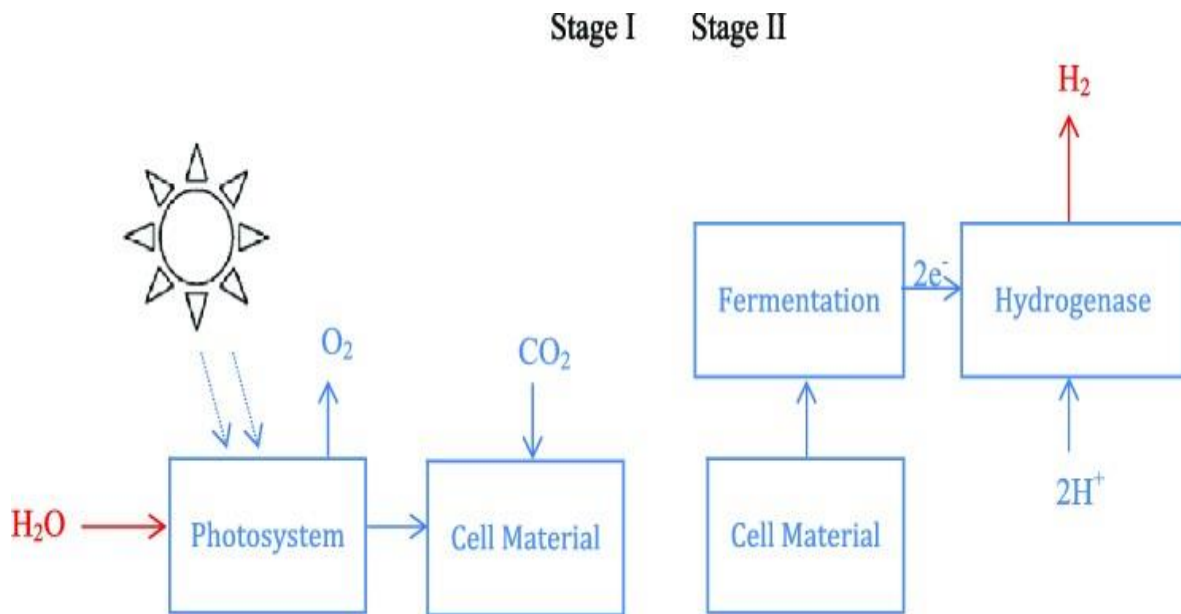


Figure 1.3.3: Indirect Bio Photolysis

PHOTOFERMENTATION (aerobic)

The production of bio hydrogen in photo fermentation is a process of converting organic compound in presence of light by usage of photosynthetic bacteria.

Bacteria responsible for photosynthesis are two types:

- I. Non-Sulphur and purple bacteria
- II. Green bacteria.

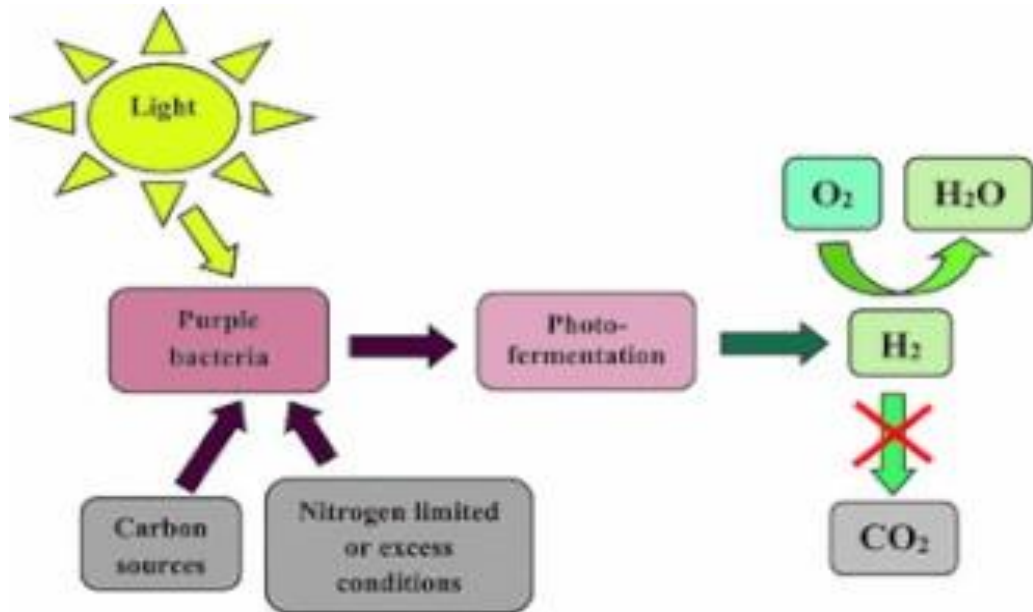


Figure 1.3.4:Photo fermentation (aerobic)

DARK FERMENTATION (anaerobic)

The production of hydrogen by heterotrophic mechanism that uses glucose as carbon source and energy from carbohydrate in absence of light and decide the energy balance in hydrogen and fermentation related products.

Advantage of dark fermentation:

- The significant benefit of this process is any organic waste can be utilized as feedstock, which helps in waste management.
- Another major benefit of dark fermentation is continuous production of biohydrogen in absence of light.
- Low energy consumption.
- Relatively higher hydrogen production and efficiently use both inorganic and organic waste as feedstock.

Disadvantages of dark fermentation:

- Biohydrogen production from dark fermentation is not commercially done because of the several condition of its production.

- Although these choices are encouraged of small scale, the financial and specialized plausibility's of executing these methods for largescale require further investigation.

1.4 FUZZY LOGIC TECHNIQUE

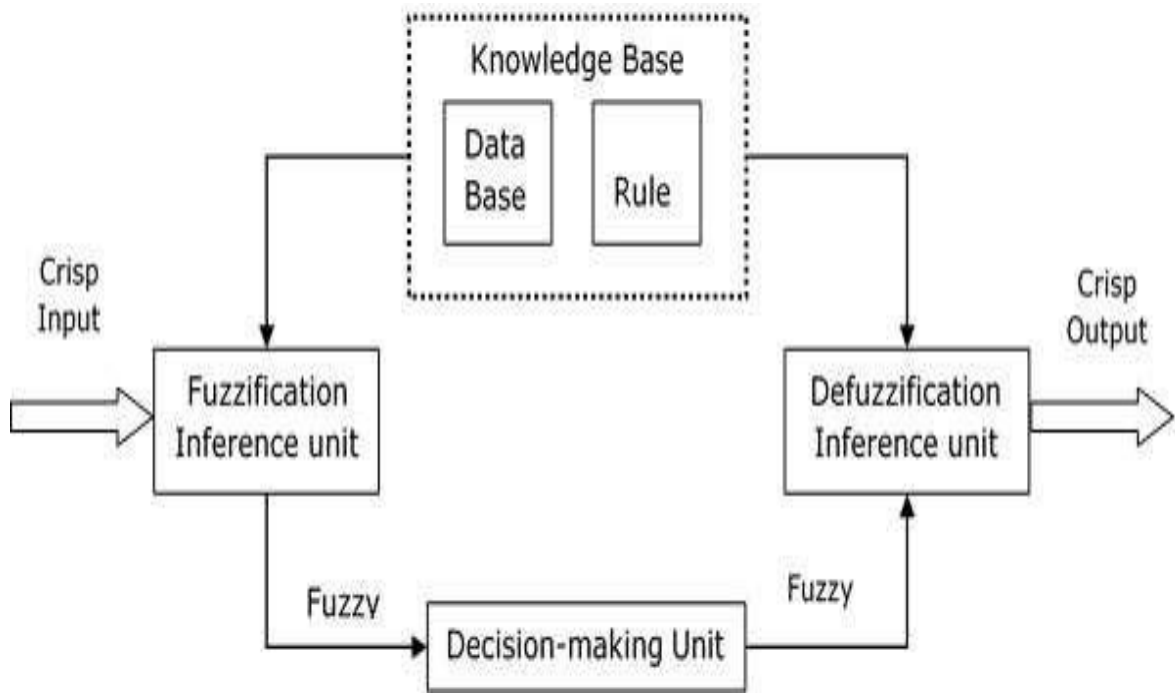


Figure 1.4.1:Fuzzy Logic Technique

- Fuzzy logic is a tool used in MATLAB for representing uncertain values.
- The complicated system can be solved by integrating the system conditions in fuzzy logic technique.
- These uses two types of controller for solving the complicated system.
 - Mamdani controller
 - Sugeno controller
- Inference system and decision making is the key unit in a fuzzy logic technique.it uses “OR” or “AND” for drawing decisions and rules.

- Mamdani system will give defuzzified output value using ranges and rule strength.
- it was used to control a boiler and steam engine combination by using set of fuzzy rules framed by the users.
- Adaptive neuro-fuzzy inference system is a artificial neural network in sugeno fuzzy inference system.it combines both fuzzy logic principles and neural network, it has potential to handle the benefits of both.
- Using back propagation algorithm neural network train by itself and give inference based on training.
- Accepts the input value and determines the membership function.
- Computation of membership degree can be done by premise parameter set.

CHAPTER 2

LITERATURE SURVEY

Table 2.1: operating conditions

No	Amount of substrate added	Operating condition	Temperature control	Hydrogen yield
1.	250kg (feed stock) Reactor volume(50l)	T=37°C	Temperature controlled water bath	12.25 ± 0.35 mol H ₂ kg ⁻¹ COD removed,
2.	500 g of FW (stored in three different temp. for 0,1,2 days) For 5°C Reactor volume(600 ml)	T=35±1°C	Water bath Agitation = 150rpm. Fermentation time=1 day	1.79, 1.72, and 1.68 mol H ₂ /mol hexose added,
3.	0.5 ml of feed slurry Reactor volume=1l	T=39±1°C P=10 ⁵ pa	Hydrogen collected =24 hrs	156–160 L H ₂ /kg TOC,FW
4.	Reactor volume=2-L (working volume 1.8 L)	T=39±1°C pH=8.5	Production time=35 hrs	10.2 NL H ₂ /kg TOC
5.	3.5 g wheat straw (acid pre-treatment at 90-120°C)	T=36±1 °C and pH 5.2-5.4	Operated for four months for getting 60% h ₂	1 mol H ₂ /mol glucose

Table 2.2: Characteristics of Substrate

Raw material	Fermentation condition	Column1	Column2
	Temperature	pressure	pH
	(°c)	(Pa)	-
cheese whey(from cow and sheep milk)	39±1°c	-	5.5
			6.5
			7.5
			8.5
cheese whey(byproduct of cheese making factory)	39±1°c		5.5
			6.5
			7.5
			8.5
cane molasses	35°c	-	6.5
distillary effluent	35°c	-	6.5
starchy waste water	35°c	-	6.5
mixed food waste	39±1°c	-	5.5
			6.5
			7.5
mixture of food waste 1	35±1°c	-	5.5
mixture of food waste 2	35±1°c	-	5.5
mixture of food waste 3	35±1°c	-	5.5
mixture of food waste 4	35±1°c	-	5.5
mixture of food waste 5	35±1°c	-	5.5
mixture of food waste 6	35±1°c	-	5.5
mixture of food waste 7	35±1°c	-	5.5
mixture of food waste 8	35±1°c	-	5.5
fresh food waste	37°c	-	6.5
pre treated food waste(100°c for 30 mins)	37°c	-	6.5
municipal organic waste(102°c for 30 mins)	35°c	-	8
fresh food waste	35±1°c	-	6.0±1
food waste stored 5°c for 1d	35±1°c	-	6.0±1
food waste stored at 5°c for 2d	35±1°c	-	6.0±1
food waste stored at 20°c for 1d	35±1°c	-	6.0±1
food waste stored at 20°c for 2d	35±1°c	-	6.0±1
food waste stored at 35°c for 1 d	35±1°c	-	6.0±1
food waste stored at 35°c for 2d	35±1°c	-	6.0±1
Rice	37±1°c		5.5
Potato	37±1°c		5.5
Lettuces	37±1°c		5.5
Lean meat	37±1°c		5.5

Column3	Column4	Characteristics of substrate	Column5	Column6	Column7
C/N	ISR	pH	TS	VS	TOC(total)
-	-	-	(g/lt)	(g/lt)	(g/lt)
-	-	4.2±0.3	75±5.8	70±4.9	22.8±2.2
-	-	4.2±0.3	75±5.9	70±4.10	22.8±2.2
-	-	4.2±0.3	75±5.10	70±4.11	22.8±2.2
-	-	4.2±0.3	75±5.11	70±4.12	22.8±2.2
-	-	6.5±0.5	63.7±4.5	58.8±4.4	27.6±6.5
-	-	6.5±0.5	63.7±4.5	58.8±4.4	27.6±6.5
-	-	6.5±0.5	63.7±4.5	58.8±4.4	27.6±6.5
-	-	6.5±0.5	63.7±4.5	58.8±4.4	27.6±6.5
-	-	4.5±1.5	998±20	798±22	-
-	-	3.8±0.5	30±2.2	22±2.1	-
-	-	7.5±0.5	25±2.2	18±1.5	-
-	0.19	3.81±0.01	43.6±2.8	40.2±1.9	25.7±3.9
-	0.19	3.81±0.01	43.6±2.8	40.2±1.9	25.7±3.9
-	0.19	3.81±0.01	43.6±2.8	40.2±1.9	25.7±3.9
21	-	-	0.41(41%)	97%	42%
21	-	-	0.39(39%)	97%	46%
23	-	-	0.40(40%)	97%	51%
25	-	-	0.40(40%)	97%	54%
15	-	-	0.40(40%)	97%	41%
9.3	-	-	0.39(39%)	97%	43%
7.1	-	-	0.39(39%)	97%	45%
5.8	-	-	0.41(41%)	96%	44%
-	-	5.0±0.3	66.2±2.6	60.4±2.3	-
-	-	5.2±0.2	65.5±1.6	60.3±1.5	-
7.2	-		5 80.6±4.2	76.8±3.8	-
-	-		6		-
-	-		6		-
-	-		5.7		-
-	-		4.3		-
-	-		4		-
-	-		4.1		-
-	-		3.9		-
47.7				8 99.50%	
35.4				8 99.50%	
12.9				9.5 84.60%	
3.6				5.3 94.90%	

Column8	Column9	Column10	Column11	Column12	Column13
TOC(soluble)	Carbohydrate(soluble)	carbohydrate(total)	Total nitrogen	COD(Total)	COD(soluble)
(g/lt)	(g/lt)	(g/lt)	(g/lt)	(g/lt)	(g/lt)
17.6±0.7	16.7±4.1	-	1.8±0.2	-	-
17.6±0.7	16.7±4.1	-	1.8±0.2	-	-
17.6±0.7	16.7±4.1	-	1.8±0.2	-	-
17.6±0.7	16.7±4.1	-	1.8±0.2	-	-
20.6±7.3	38±6.3	-	0.94±0.2	-	-
20.6±7.3	38±6.3	-	0.94±0.2	-	-
20.6±7.3	38±6.3	-	0.94±0.2	-	-
20.6±7.3	38±6.3	-	0.94±0.2	-	-
-	-	750±20	-	900±50	880±30
-	-	9.5±0.8	-	58±2.0	38±1.8
-	-	13±2.5	-	25±2.2	20±1.5
9.6±0.8	14.0±1.9	23.1±6.7	-	-	-
9.6±0.8	14.0±1.9	23.1±6.7	-	-	-
9.6±0.8	14.0±1.9	23.1±6.7	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	52.7±1.2	-	60.4±7.8	-
-	-	55.4±1.8	-	62.2±6.5	-
-	-	84.1±5.3	-	142.3±15.1	-
-	-	119.6	-	230.1	50.7
-	-	126.8	-	235.3	55.1
-	-	124.9	-	238.2	59.1
-	-	125.7	-	243.4	69.3
-	-	121.4	-	252.8	70.6
-	-	127.5	-	251.1	70.3
-	-	124.5	-	259.4	79.3
		42.63%	0.89%		
		41.36%	1.17%		
		42.12%	3.26%		
		50.97%	13.11%		
		76.40%	0.01%		

Column14	Column15	Column16	Column17	Column18	Column19
TKN	Ammonia (total)	Ammonia (soluble)	lipid	protien	Carbohydrate
(g/lt)	mg/lt	mg/lt			
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
0.5±2.8	-	-	-	-	-
5.31±0.8	-	-	-	-	-
0.1±0.08	-	-	-	-	-
-	210.2±8.8	203.9±33.6	-	-	-
-	210.2±8.8	203.9±33.6	-	-	-
-	210.2±8.8	203.9±33.6	-	-	-
2.00%	-	-	15%	12%	68%
2.20%	-	-	26%	13%	57%
2.20%	-	-	39%	13%	44%
2.20%	-	-	48%	13%	36%
2.70%	-	-	15%	16%	63%
4.60%	-	-	15%	27%	53%
6.30%	-	-	15%	37%	43%
7.60%	-	-	15%	45%	34%
-	-	-	-	1.9±0.3	-
-	-	-	-	1.8±0.5	-
-	-	-	-	21.4±3.2	-

[illegible]

Table 2.3.1: Proximate analysis

Sl. No	Raw material	Fermentation condition		Characteristics of Raw Material							Hydrogen yield
		T(°C)	pH	pH	TS	VS	TOC (T)	TOC (S)	CARBO	TN	
1	Cheese whey-1 (from cow milk and sheep milk)	39±1 ⁰ c	5.5	4.2±0.3	75±0.5	70±4.9	22.8±2.2	17.6±0.7	16.7±4.1	1.8±0.2	0.1
			6.5								20.6
			7.5								45.1
			8.5								5.1
2	Cheese whey (by product of cheese making factory made of cow milk)	39±1 ⁰ c	5.5	6.5±0.5	63.7±4.5	58.8±4.4	27.6±6.5	20.6±7.3	38±6.3	0.94±0.2	-
			6.5								85.5
			7.5								50.7
			8.5								-

INFERENCE

In this particular paper, hydrogen production by using cheese whey obtained from two different sources and the influence of operating pH were investigated. the higher hydrogen production for cheese whey(1) is observed at pH of 7.5. when the pH is decreased, hydrogen production is also decreased simultaneously. In experiments carried out for cheese whey(2) without inoculum it is not as same as result obtained in cheese whey(2). For second experiment hydrogen production rate is very low. In the first experiment, which have been carried out for short (3 days), they have reported that there is no methane is detected although adopted pH would have led to methanogenesis and no pretreatment applied. This clearly shows that operating pH and inoculum plays major role in hydrogen production.

Table 2.3.2: proximate analysis

Sl. No	Raw material	Fermentation condition	Characteristics of Substrate						Hydrogen yield (ml/g(vs))
			pH	TS	VS	COD	CARBO	PROTEIN	
1	Mixed food waste (without pretreatment)	T= 37 ⁰ c pH = 6.5	5.0	66.2	60.4	60.4	52.7	1.9	16.1
2	Mixed food waste (pretreated)	T= 37 ⁰ c pH = 6.5	5.2	65.5	60.3	62.2	55.4	1.8	

Table 2.3.3:Proximate analysis

S. No	Raw materials	Fermen tation condition	Characteristics of Substrate								Hydro gen yield (%)
			TS	VS	TOC	TKN	C/N	Lipid	Protein	Carbon	
1.	Raw material 1	T=35 ⁰ c Ph=5.5	41	39	42	2.0	21	15	12	68	53
2.	Raw material 2	T=35 ⁰ c Ph=5.5	39	97	46	2.2	21	26	13	57	53
3.	Raw material 3	T=35 ⁰ c Ph=5.5	40	97	51	2.2	23	39	13	44	54
4.	Raw material 4	T=35 ⁰ c Ph=5.5	40	97	54	2.2	25	48	13	36	54
5.	Raw material 5	T=35 ⁰ c Ph=5.5	40	97	41	2.7	15	15	16	63	53
6.	Raw material 6	T=35 ⁰ c Ph=5.5	39	97	43	4.6	9.3	15	27	53	55
7.	Raw material 7	T=35 ⁰ c Ph=5.5	39	97	45	6.3	7.1	15	37	43	54
8.	Raw material 8	T=35 ⁰ c Ph=5.5	41	96	44	7.6	5.8	15	45	34	57

The effects of chemical composition of organic waste on dark fermentation process and carbon transformation. protein and lipid have mere contribution whereas biogas and hydrogen production are linearly correlated. bio hydrogen carbohydrate is the key parameter to identify suitable organic waste.

Table 2.3.4: proximate analysis

S. No	Raw material	Fermen tation condition	Characteristics of Substrate							Hydro gen yield
			TS	pH	TCOD	SCOD	TC	TKN	VS	
1.	Cane molass	T= 35 pH=6.5	998±20	4.5±1.5	900±50	880±30	750±20	798±22	798±22	5.14
2.	Distillery	T=35 Ph=6.5	30±2.2	3.8±0.5	58±2.0	38±1.8	9.5±0.8	5.31±0.8	22±2.1	4.24
3.	Strach water	T=35 Ph=6.5	25±2.2	7.5±0.5	25±2.2	20±1.5	13±2.5	0.1±0.08	18±1.5	2.1±

Bio hydrogen production by anaerobic digestion of foodwaste was the pathway. anaerobic digestion process was carried out using appropriate bacteria under optimized operation condition.

Table 2.3.5: Proximate analysis

S. No	Raw Material	Fermentation Condition		Characteristics of Substrate						H2 yield	Hydro genyield
		T(C)	pH	pH	TS	VS	TOC	Tot. Carbohydrate	Sol. Carbohydrate	SC	
	Food waste	39±1°C	5.5 6.5 7.5	3.8±0.01	43.6±2.8	40.2±1.9	25.7±3.9	23.1±6.7	14±1.9		

The process yield was affected by pH and ISR. Kinetics and biochemical pathways are carefully optimized to get maximum yield.

CHAPTER 3

AIM

To predict the hydrogen yield using the fuzzy logic technique.

SCOPE

- Prediction of hydrogen yield without performing the actual experiment.
- Segregation of raw material according to parameters influencing hydrogen yield.
- Designing of bioreactor based on the nature and amount of raw material required.
- Optimization of process parameters.

CHAPTER 4

4.1 BLOCK FLOW DIAGRAM

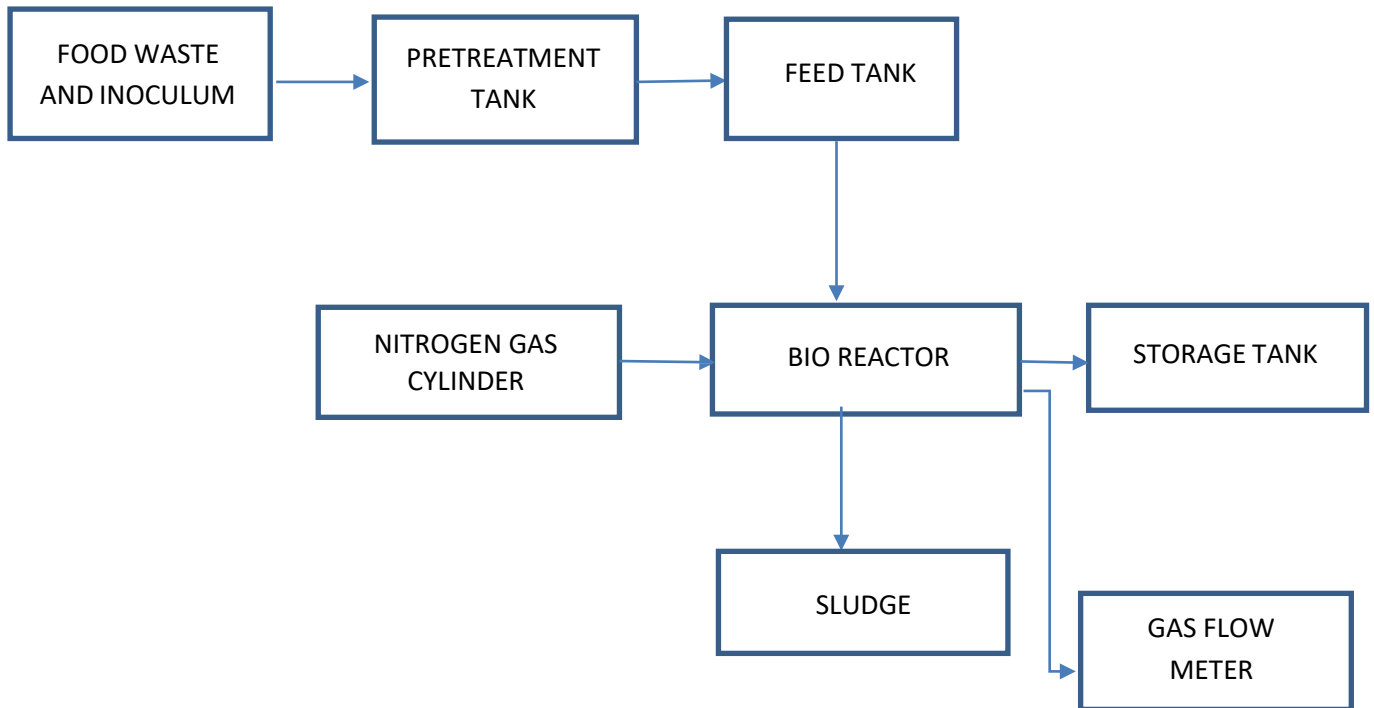


Figure 4.1:

PROCESS DESCRIPTION

- Food waste and inoculum are made into slurry. Feed slurry is pre-treated to 120°C using steam for killing methanogens.
- Temperature of slurry is reduced storing it in feed tank for several hours. From the feed tank slurry is fed into bio-reactor.
- Temperature of bio-reactor is maintained at 39°C. Nitrogen gas is purged into the reactor since it is an anaerobic fermentation; oxygen must be removed from the reactor.
- Biogas is stored in storage tank and flow of gas is measured by gas flow meter.
- Sludge is removed from the bottom of the reactor.

4.2 PROCESS FLOW DIAGRAM

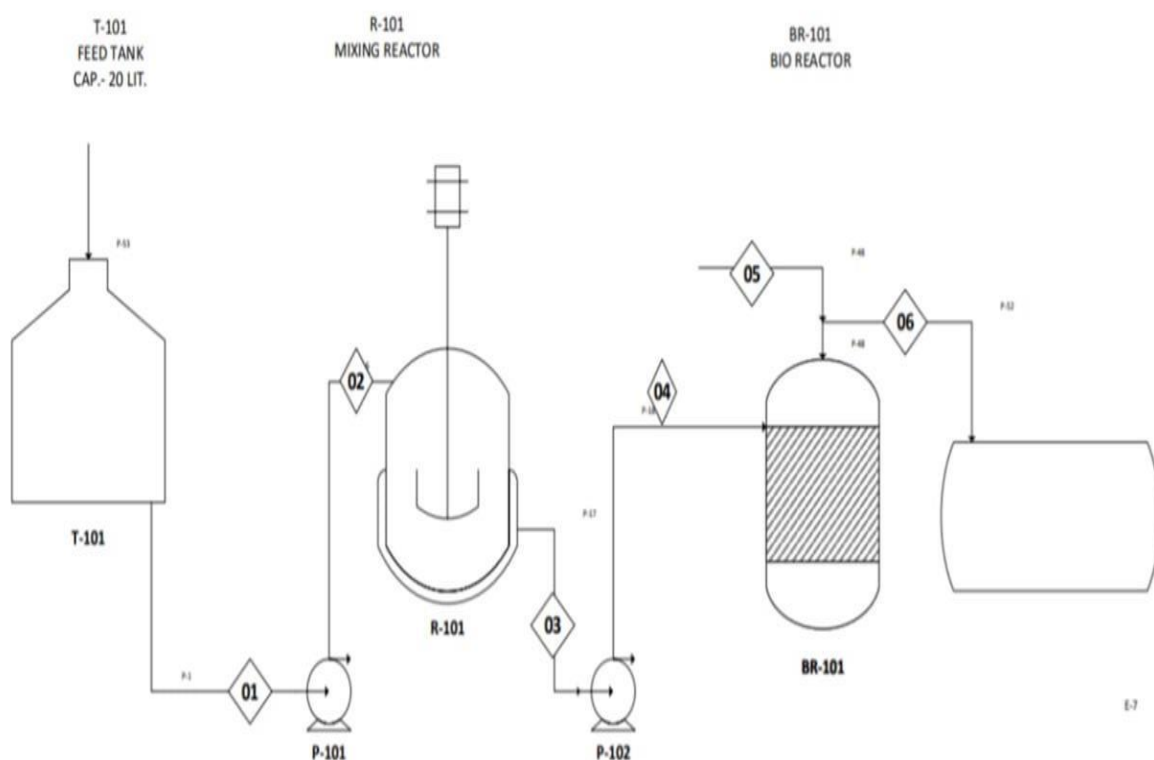


Figure 4.2.1:Process Flow Diagram

Steam number	1	2	3	4	5	6
TEMPERATURE(°C)	32	32	120	120	37	37
PRESSURE (atm)	1	1	1	1	1	1
VAPOUR PRESSURE	0	0	0	0	0	0

TABLE 4.1.2: DATA FOR STOICHIOMETRY

Source	Reactor volume	Inoculum volume	pH	Time taken	Hydrogen yield
Food waste	500ml	125ml	7.5	34h	75l /kg TOC_{FW}
Food Waste	100ml	20ml	5.2±0.2	24h	75.3ml/ g_{VS}
Food waste	300ml	100ml	6.0	5-7h	1.7-1.8mol H_2 /mol $hexose_{added}$
Municipal organic waste (carbohydrate and protein)	600ml	-	10	192h	21ml/ g_{tcd}
Cheese whey	1.8l (1800ml)	200ml	6.5-7.5	24h	171.3NL H_2 /kg toc

TABLE 4.1.3 INOCULUM VOLUME

SI. No	WORKING VOLUME OF REACTOR (ml)	VOLUME OF INOCULUM ADDED (ml)	CALCULATED FOOD WASTE VOLUME (ml)	INCORPORATED DENSITY FACTOR (ρ)
1.	500	125	250	for inoculum $\rho(in)=1400g/cc$ for food waste $\rho(fw)=11864g/cc$

CALCULATION

$$W(fw) = V(fw) * \rho(fw) = 250\text{cc} * 11864\text{g/cc}$$

$$= 2966000\text{g}$$

$$= 296.600\text{kg}$$

$$W(in) = V(in) * \rho(in) = 125\text{cc} * 1400\text{g/cc}$$

$$= 175000\text{g}$$

$$= 175\text{kg}$$

$$296.600\text{ kg of food waste} = 175\text{ kg of inoculum}$$

For 1000kg of food waste

$$\text{Inoculum} = 175\text{kg} * 1000\text{kg} / 296.600\text{kg}$$

$$= 591\text{kg}$$

MIXER

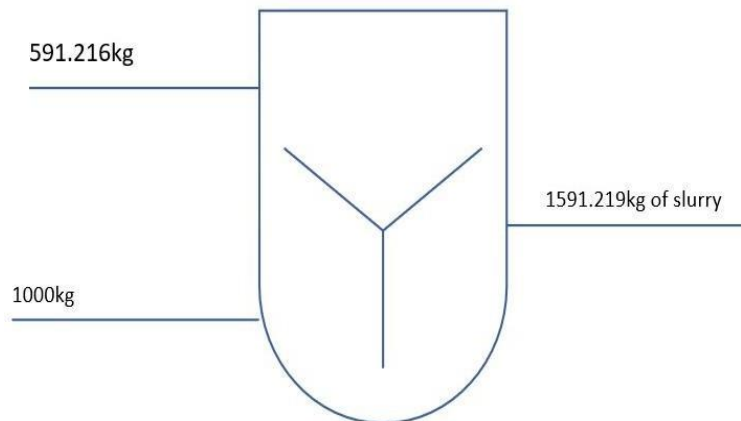


TABLE 4.3.1: MATERIAL BALANCE

EQUIPMENT	INPUT	OUTPUT
MIXER	INOCULUM=591.216 Kg FOOD WASTE=1000Kg	519.216kg+1000kg= 1591.216 kg 1591.216kg of feed slurry

PRETREATMENT TANK

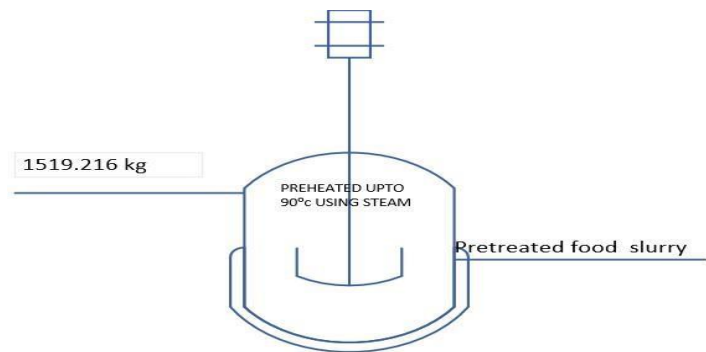


TABLE4.3.2: Pretreatment Tank

EQUIPMENT	INPUT	OUTPUT
PRETREATMENT TANK	FEED SLURRY=1519.216kg STEAM= 221231kg	1519.216kg food slurry is heated to using 90°C the steam of 22123.

BIOREACTOR

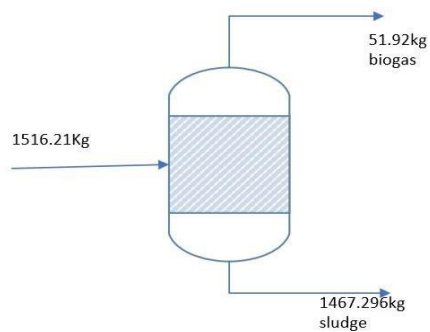


TABLE4.3.3: Bioreactor

EQUIPMENT	INPUT	OUTPUT
BIO REACTOR	FEED SLURRY=159.216kg ASSUME 10% CONVERSION	1519.216 kg=51.92 kg+467.296kg HYDROGEN YIELD =51.92kg SLUDGE= 467.296

4.4 ENERGY BALANCE

PRETREATMENT TANK

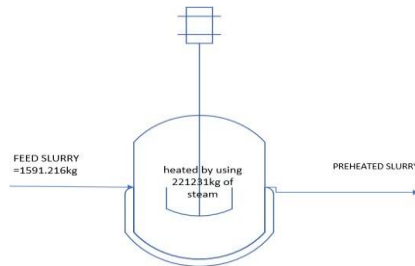


TABLE 4.4.1: Pretreatment Tank

EQUIPMENT	INPUT	OUTPUT
PRE-TREATMENT TANK	FEED SLURRY =1591.216kg $mcp\Delta t=m\lambda$ $1519.216\text{kg}\cdot 4184\text{KJ/kg}^0\text{c}\cdot 75^0\text{c}$ $=m\cdot 2257\text{KJ/kg}$ $m=221231\text{kg}$	Feed slurry is heated by using 221231kg of steam

BIOREACTOR

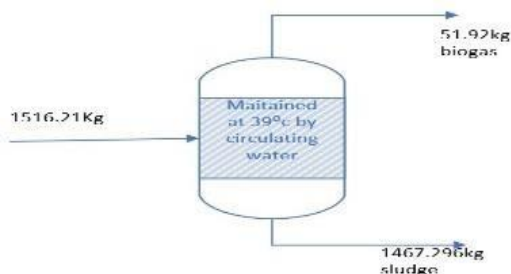


Figure 4.4.2: Bioreactor

EQUIPMENT	INPUT	OUTPUT
BIOREACTOR	PRETREATED SLURRY =1591.216kg $(m\ cp\ \Delta t)\ h = (m\ cp\ \Delta t)\ c$ $m\cdot 4182\text{KJ/kg}^0\text{c}\cdot 20^0\text{c}$ $=1519.216\text{kg}\cdot 4182\text{KJ/kg}^0\text{c}\cdot 11^0\text{c}$ $m=835.56\text{kg}$	Temperature of reactor is maintained at 37^0c with help of hot water.

CHAPTER 5

5.1 METHODS AND ALGORITHM

5.1.1 MAMDANI CONTROLLER

STEP 1: Select the key parameters that influence the hydrogen production from the collected data.

STEP 2: Check the minimum and maximum value of available data, according to that fix the range for the input and output.

STEP 3: Add the member function based on the assigned input and output.

STEP 4: Assign the fixed value of range for the particular input and output to the tool.

STEP 5: Frame the rule by using data that are available.

STEP 6: Compare the data that are obtained from literature survey with the data obtained from the matlab.

STEP 7: using that we can predict the hydrogen yield for unavailable data.

STEP 8: validation have been made.

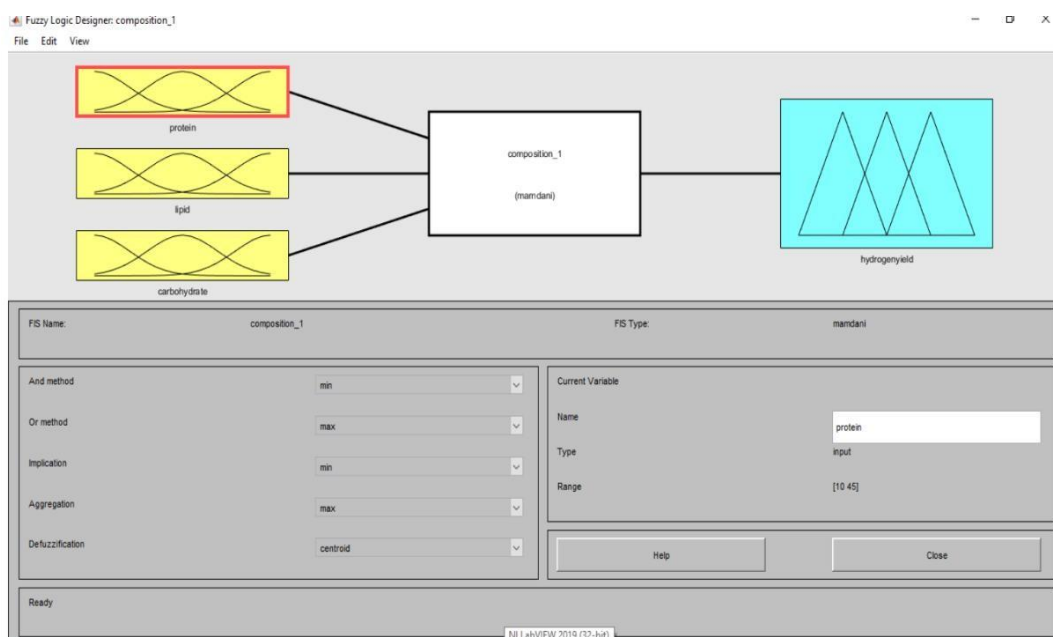


Figure 5.1.1: VARIABLES

MAMDANI INFERNCE SYSTEM

- Inference system and decision making is the key unit in a fuzzy logic technique. it uses “OR” or “AND” for drawing decisions and rules.
- Mamdani controller was proposed by Ebhasim Mamdani in 1957.
- it was used to control a boiler and steam engine combination by using set of fuzzy rules framed by the users.
- this system will give defuzzified output value using ranges and rule strength.

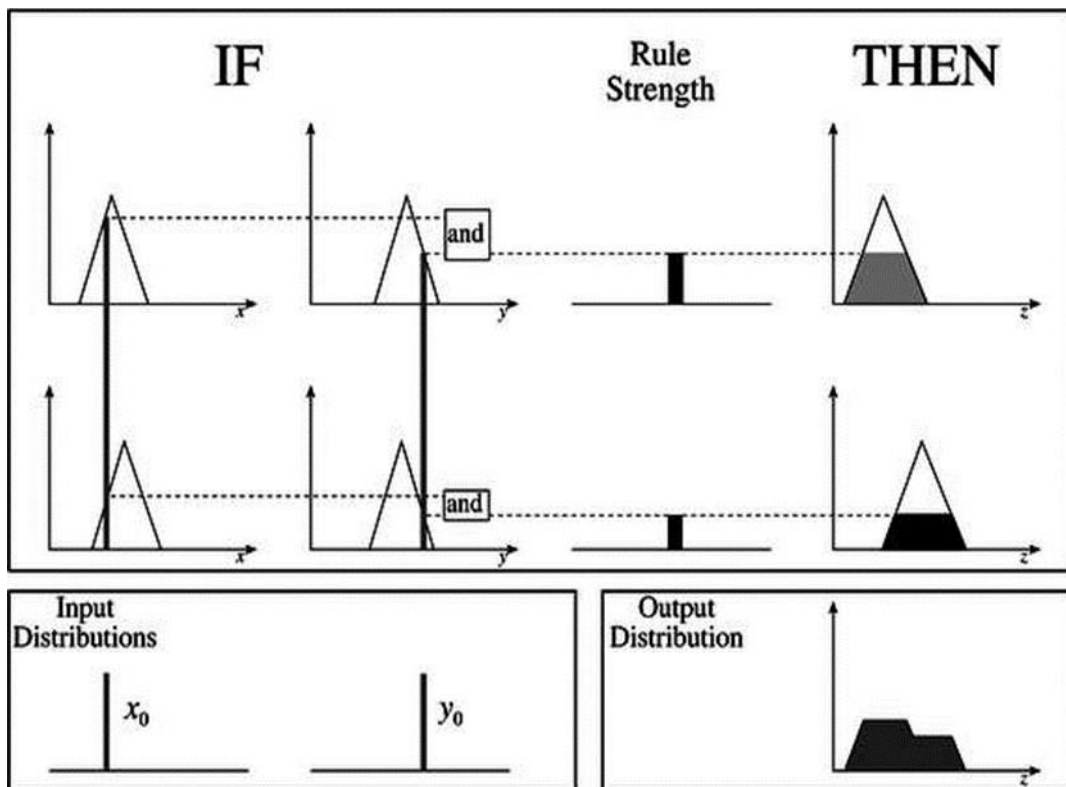


Figure 5.1.2: Mamdani Infernce System

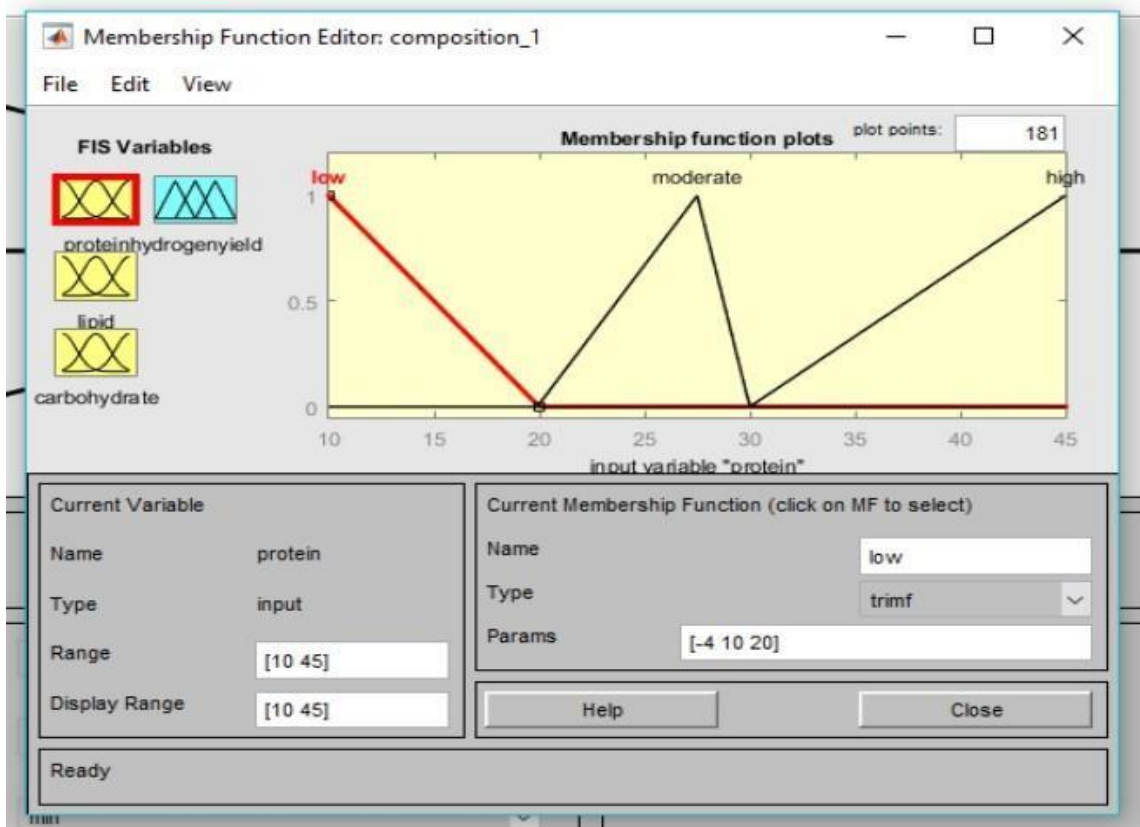


Figure 5.1.3:MEMBER FUNCTION

Table 5.1: RULE TABLE

LIPID				
PROTEIN	L	M	H	CARBOHYDRATE
L	L	L	L	L
L	H	L	M	M
L	H	H	M	H
M	M	M	L	L
M	H	M	M	M
M	M	H	M	H
H	L	M	M	L
H	M	H	M	M
H	H	H	H	H

L = LOW; M = MODERATE; H = HIGH

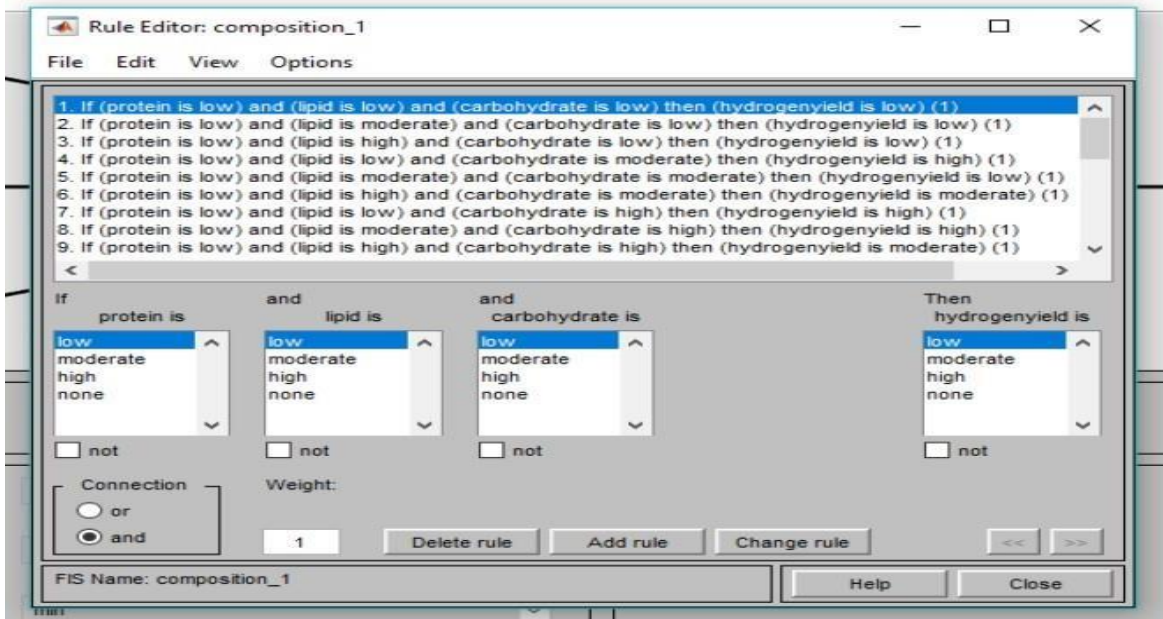


Figure 5.1.4:RULE

RESULT:

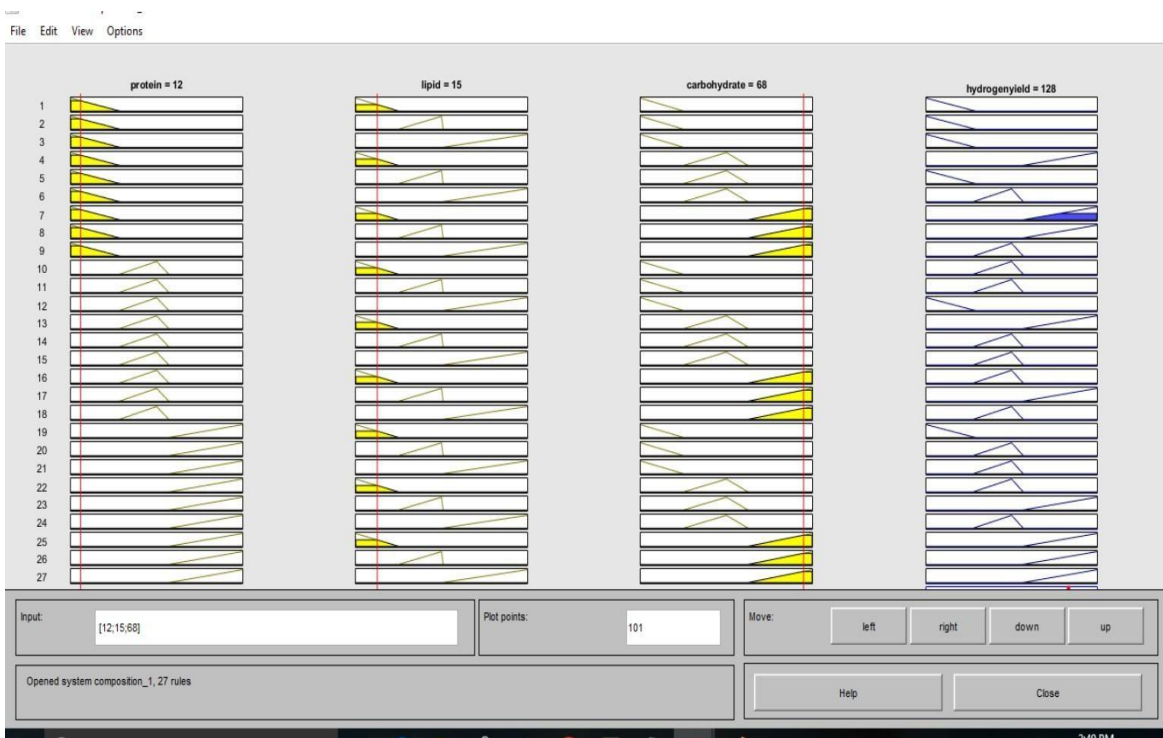


Figure 5.1.5: RESULT

5.2 SUGENO CONTROLLER

STEP 1: Add variable for input and output.

STEP 2: Create null in workspace.

- i. INPUT DATA.
- ii. OUTPUT DATA.
- iii. TEST DATA.

STEP 3: Assign the value that have to be trained.

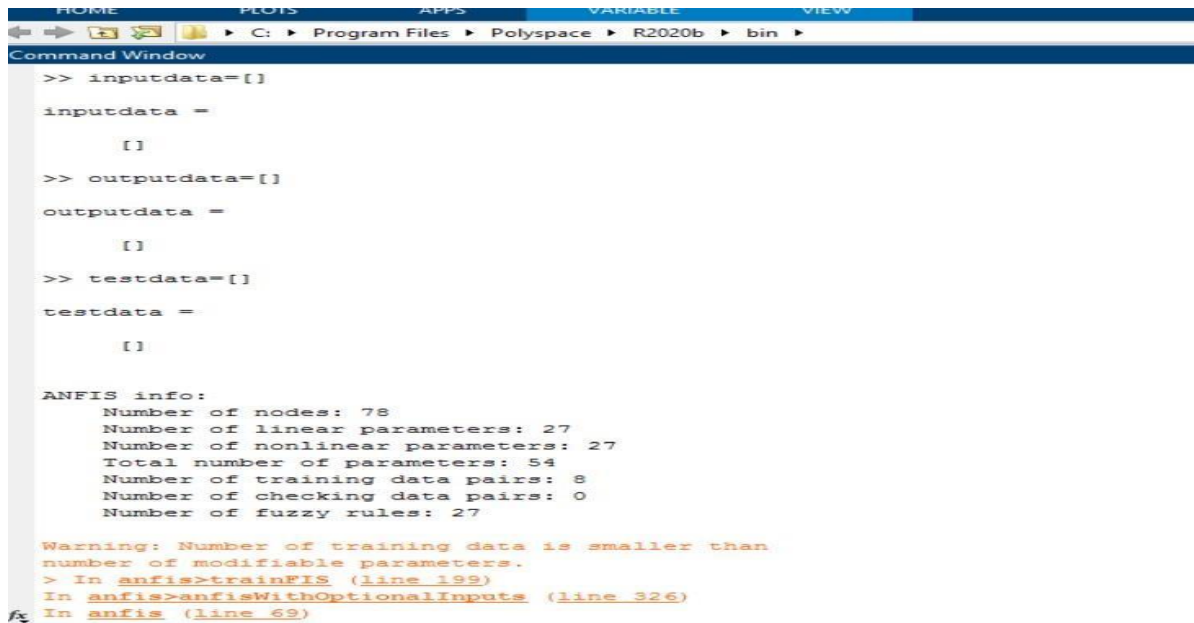
STEP 4: Click on ANFIS for training data.

STEP 5: Import variables from workspace.

STEP 6: Using the data given Neural Network will train by itself and give inference based on training

STEP 7: View on rule to obtain output.

COMMAND FOR CREATION VOID AND ANFIS INFORMATION:



```
>> inputdata=[]  
inputdata =  
    []  
>> outputdata=[]  
outputdata =  
    []  
>> testdata=[]  
testdata =  
    []  
  
ANFIS info:  
  Number of nodes: 78  
  Number of linear parameters: 27  
  Number of nonlinear parameters: 27  
  Total number of parameters: 54  
  Number of training data pairs: 8  
  Number of checking data pairs: 0  
  Number of fuzzy rules: 27  
  
Warning: Number of training data is smaller than  
number of modifiable parameters.  
> In anfis>trainFIS (line 199)  
In anfis>anfisWithOptionalInputs (line 326)  
In anfis (line 69)
```

Figure 5.2.1:COMMAND SCREEN

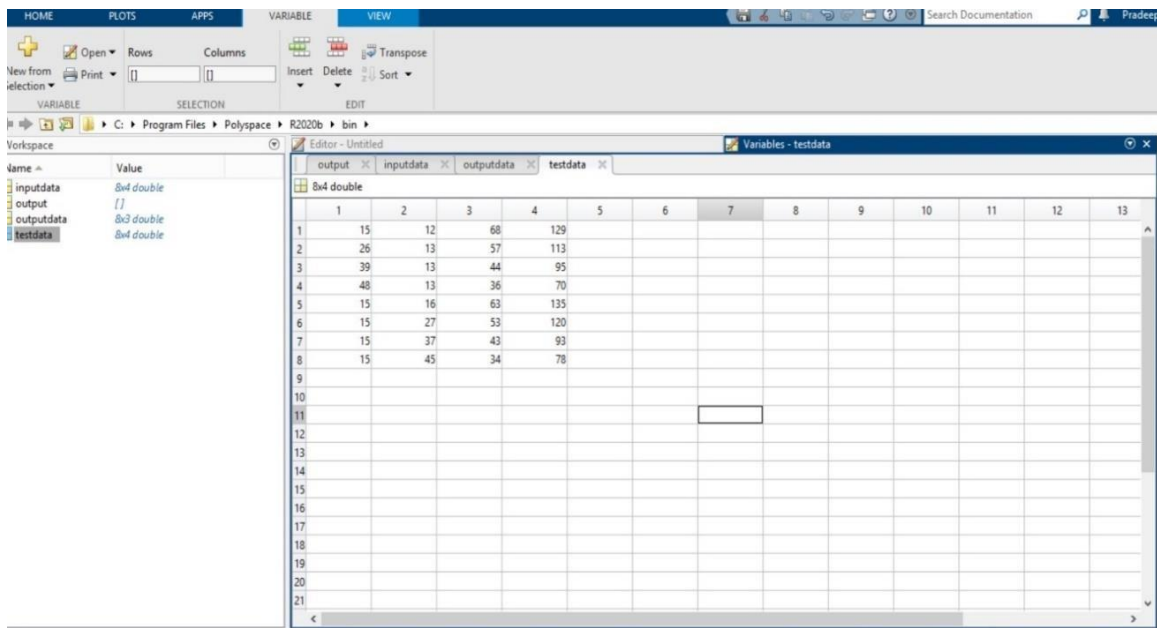


Figure 5.2.2:WORK SPACE

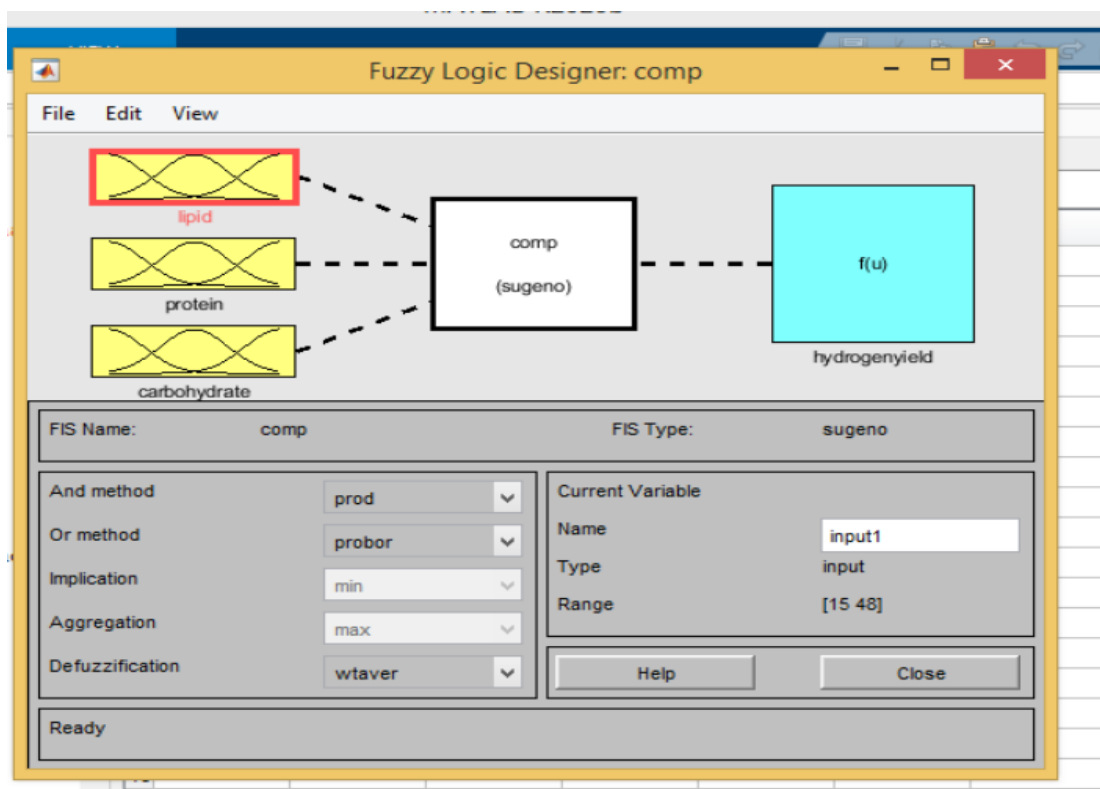


Figure 5.2.3:MEMBER FUNCTION

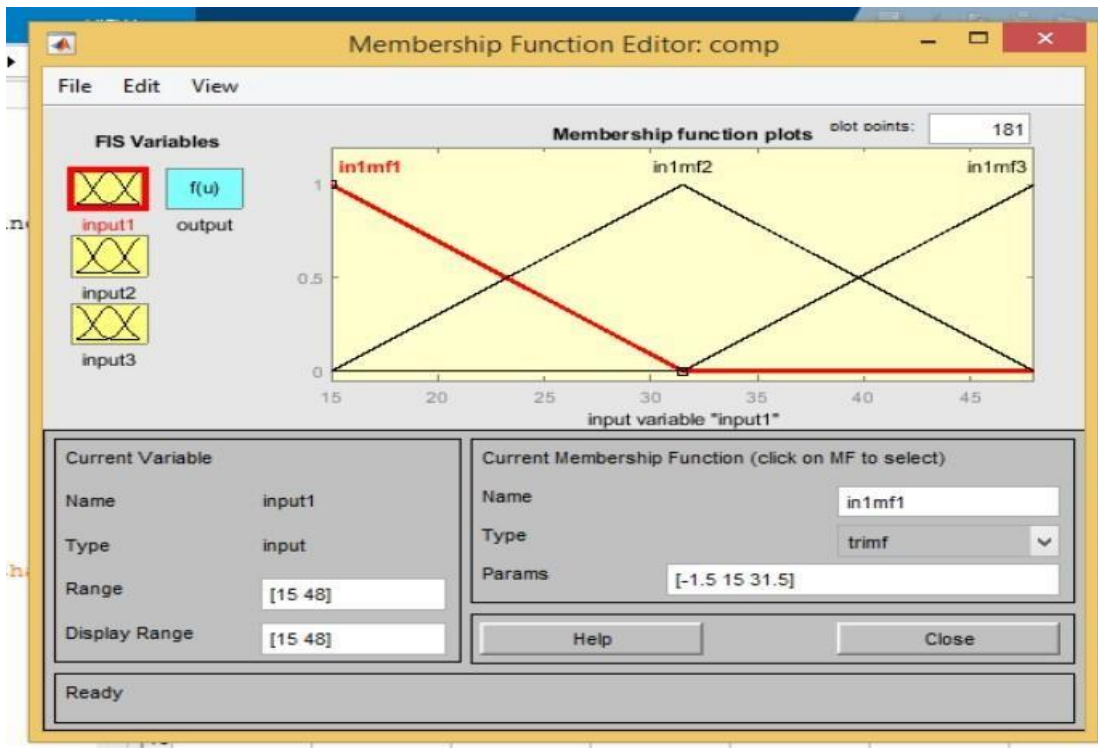


Figure 5.2.4: MEMBER FUNCTION

ADAPTIVE NEURO FUZZY INFERENCE: (ANFIS)

Adaptive neuro-fuzzy inference system is a artificial neural network in sugeno fuzzy inference system.it combines both fuzzy logic principles and neural network, it has potential to handle the benefits of both.

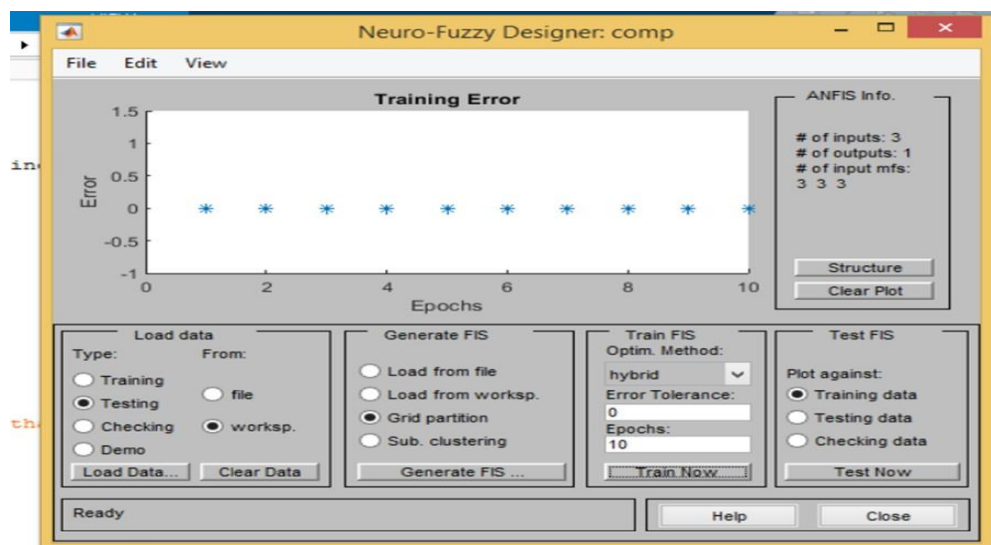


Figure 5.2.5: TRAINING SCREEN

The network structure consists of two parts consequence and premise part.

ANFIS is composed of five layers.

- I. Fuzzification layer
- II. Rule layer
- III. Normalizing layer
- IV. Consequence
- V. Defuzzification

PLOT OF TRAINED VALUE

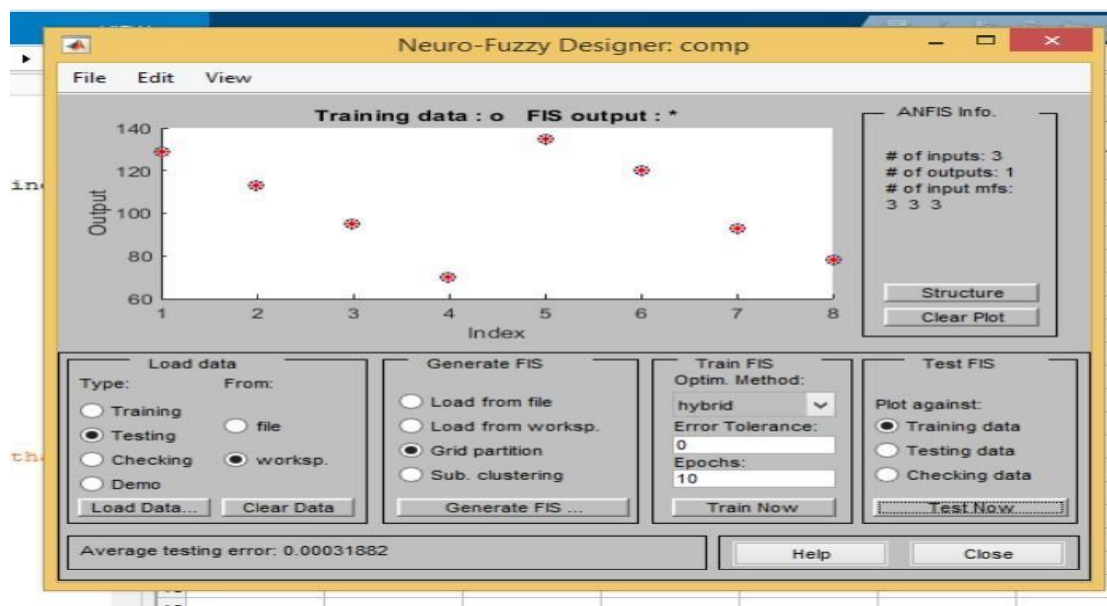


Figure 5.2.6: TRAINED VALUE

Using back propagation algorithm neural network train by itself and give inference based on training.

ADAPTIVE NEURAL NETWORK:

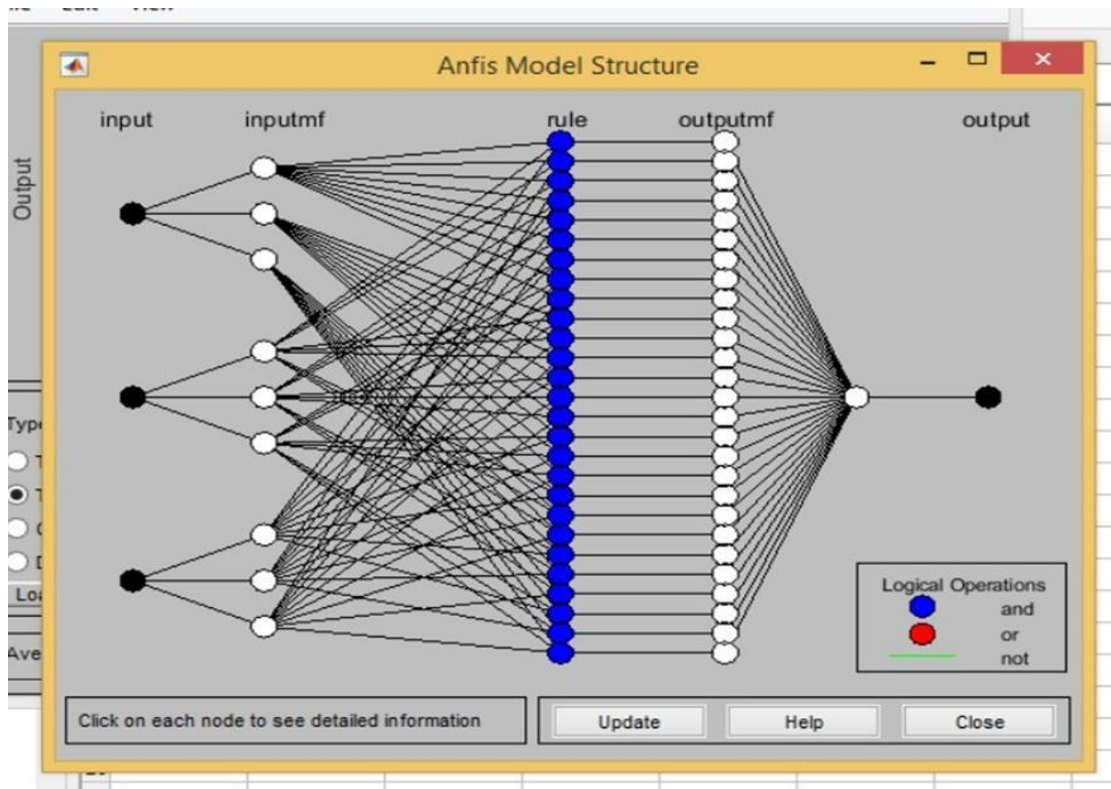


Figure 5.2.7; Adaptive Neural Network

FUZZIFICATION LAYER

- I. Accepts the input value and determines the membership function.
- II. Computation of membership degree can be done by premise parameter set.

RULE LAYER

- III. Responsible for generating the strength for the rules.

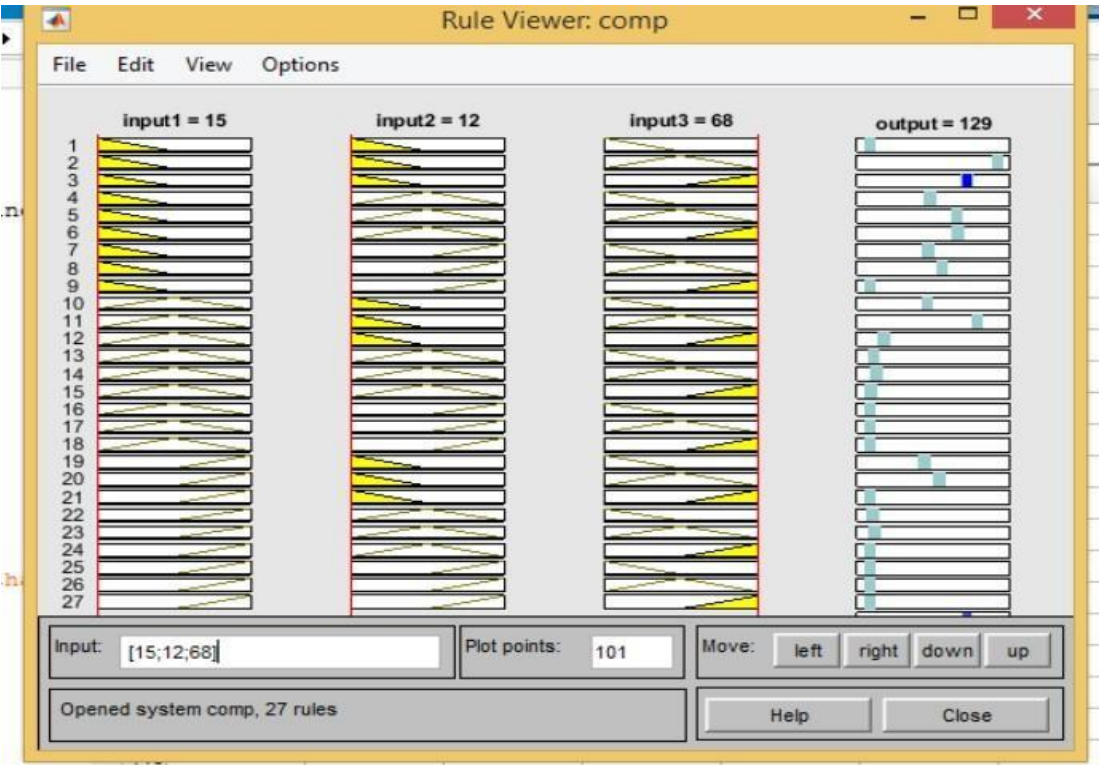
THIRD LAYER

- IV. Normalising the computed strength of input.

CONSEQUENCE LAYER

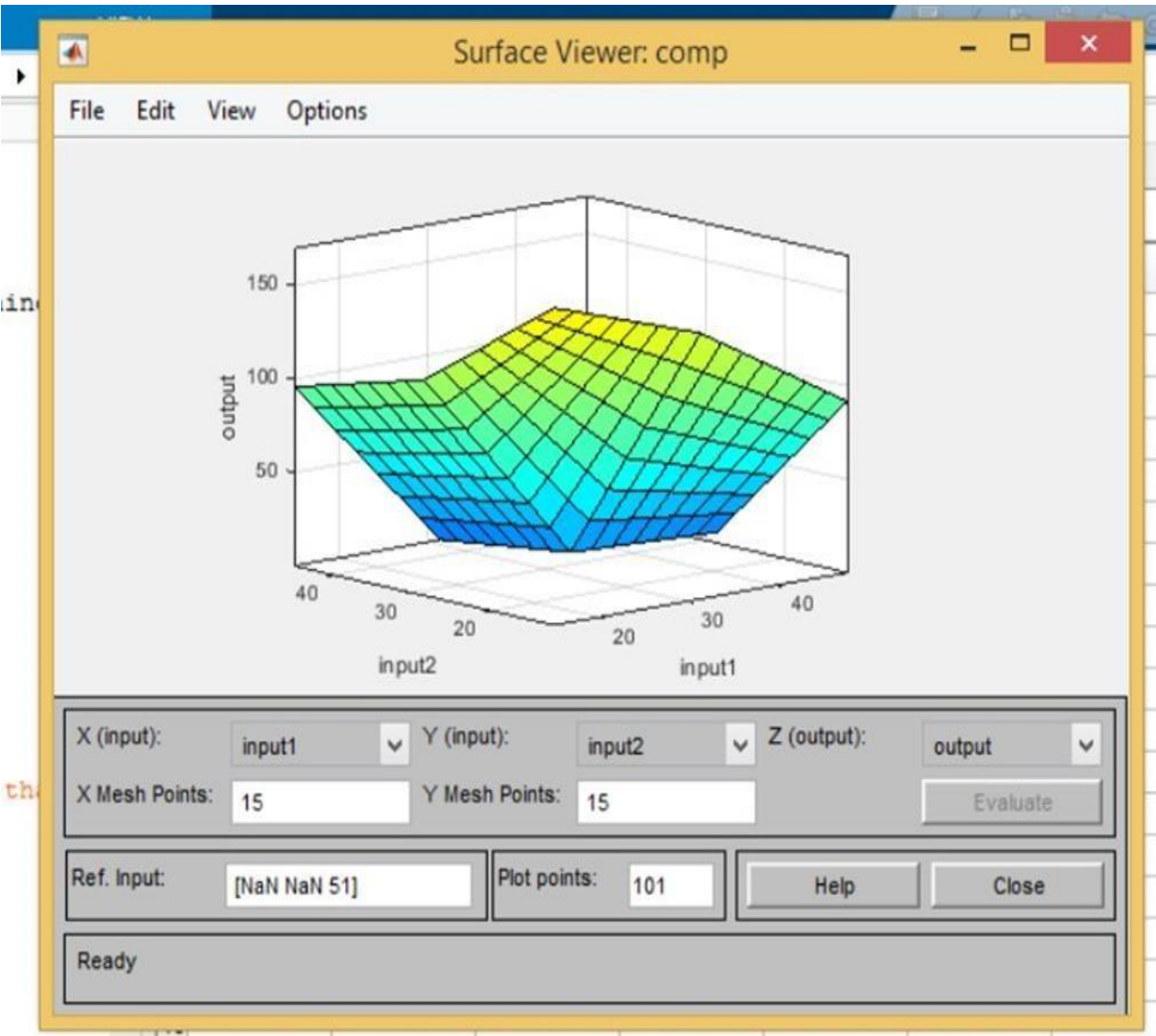
- V. Take the normalised input and consequence the parameters.
- VI. The result of the above step is defuzzification and return final output.

5.2.8 RESULT



SURFACE IMAGE OF PLOT INPUT 1 VS INPUT 2 AND PLOT INPUT 2 AND INPUT 3

Figure 5.2.9; SURFACE IMAGE 1



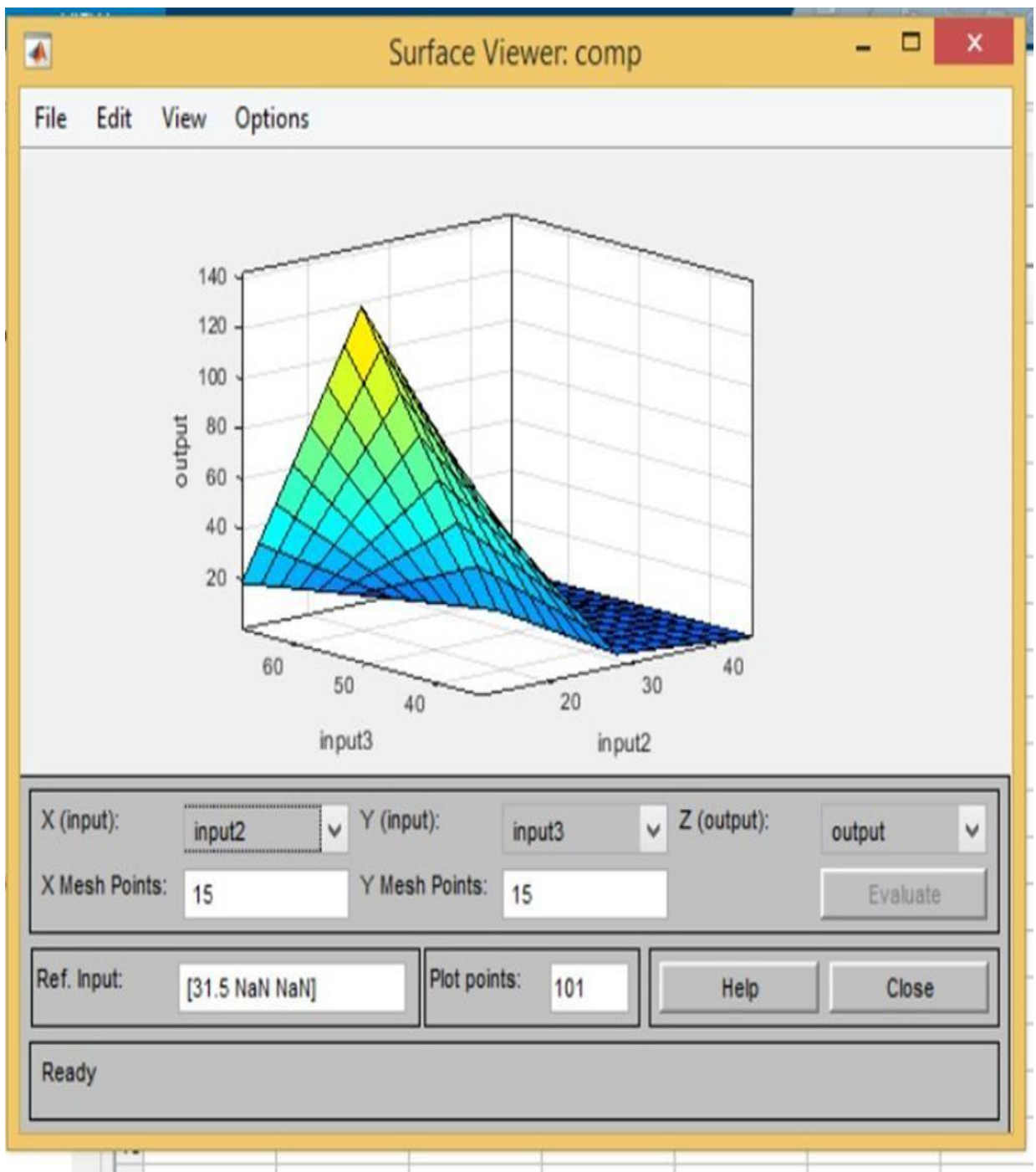


Figure 5.2.10: SURFACE IMAGE 2

5.3 VALIDATION

MAMDANI CONTROLLER

Lipid(%)	Protein(%)	Carbohydrate(%)	Hydrogen yield(literature survey)(ml/g(vs))	Hydrogen yield(predicted) (ml/g(vs))	deviation
15	12	68	129	128	1
26	13	57	113	120	7
39	13	44	95	100	5
48	13	36	70	78	8
15	16	63	135	128	7
15	27	53	120	128	8
15	37	43	93	100	7
15	45	34	78	77.6	2

Lipid (%)	Protein (%)	Carbohydrate (%)	Hydrogen yield (literature survey) (ml/g(vs))	Hydrogen yield(predicted) (ml/g(vs))	deviation
15	12	68	129	129	-
26	13	57	113	113	-
39	13	44	95	95	-
48	13	36	70	70	-
15	16	63	135	135	-
15	27	53	120	120	-
15	37	43	93	93	-
15	45	34	78	78	-

SUGENO CONTROLLER: (NO ERROR)

RESULT:

The results of Mamdani inference system have some deviation. But in case of sugeno inference system deviation is zero so we can conclude that prediction of hydrogen yield can be done accurately using sugeno inference system. We can discuss about the difference between both inference system.

- I. Output membership function is the major difference between them. Sugeno has linear or constant output membership function.
- II. Defuzzification method is different and in sugeno neural network train by itself and give the inference based on training.

To get a hydrogen yield for unknown data, the available data from literature survey should be tested and validated. The rules should be carefully made for Mamdani controller the deviation might occur due to the user carelessness while framing rules. sugeno controller working on adaptive neuro fuzzy logic inference system which will train data itself using back propagation. As it has been done by ANFIS there is no chance of deviation. For this the user should provide a greater number of input data. it will train on training data and we can get values for test data.

For assigning the key input user should be familiar with the influencing factor for hydrogen yield in anaerobic fermentation, characteristic of feed etc., carbohydrate, protein, lipid, COD, VS are some properties of feed that affect the hydrogen yield. Higher Carbohydrate content gives better hydrogen yield up to 50%. protein also have increases hydrogen yield. Lipid does affect the yield up to certain amount if it is in higher percentage hydrogen yield will reduce drastically.so it is very important to select the key input for validating this model.

CHAPTER 6

SUMMARY AND CONCLUSION

The project on prediction of bio hydrogen from food waste using low level artificial intelligence method, fuzzy logic technique has done. Literature survey was done to understand about the amount of substrate, operating condition & hydrogen yield. Based on the literature survey the characteristics of food waste was screened. Process flow diagram and block diagram was developed, which have strengthened knowledge in this field. The material and energy balance have been discussed for mixer, pre-treatment tank & bio reactor. calculation part was also done. The training for fuzzy logic technique have undergone, which will help to understand about it. In Fuzzy logic technique the prediction of the output for the unavailable data can be done. Two–three set of data was taken to predict the yield of hydrogen using fuzzy logic technique and the output and validation is attached along with the report. Using this technique, the prediction of hydrogen yield for the unsure data by giving data taken from literature survey as input have been done.

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