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Optimization of Bioethanol Producer in Kenana Ethanol Plant

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Abstract- This study focuses on to determine the optimization of bio ethanol plant in Kenana to produce product at high quality and maximum income. The different samples of (Beer, mash ,molasses ,and ethanol at different concentration (75% , 92% ,99.8%) for different unit was taken and analyzed and studies their result to determined the properties which effect in the quality of ethanol and production rat like -Total reducing sugar (TRS), polarization(pol), Brix, conductivity, Acidity, appearance, ethanol concentration, (pH) , yeast concentration , density .

And vinasse sample was taken and analyzed to determined concentration of ethanol, Biochemical oxygen and chemical oxygen demand. Then studies the environmental impact of vinasse and how to reduce it.

I. Introduction

Ethanol:

Bio-Ethanol is an alcohol-based fuel made by fermenting and distilling starch crops, such as corn and fermenting of molasses. It can also be made from "cellulosic biomass" such as trees and grasses. The use of ethanol can reduce our dependence upon foreign oil and reduce greenhouse gas emissions. The use of ethanol as a fuel for internal combustion engines, either alone or in combination with other fuels, has been given much attention mostly because of its possible environmental and long-term economical advantages over fossil fuels [1].

Bioethanol Production:

In addition to raw sugar, the mills produce useful by-products such as molasses and bagasse. Molasses is the dark syrup separated from the raw sugar crystals during the milling process. It is used as a raw material in distilleries where industrial alcohol (such as ethanol),ethanol process by fermentation of molasses ,the process takes place in many steps. First the dilute molasses feed in fermented with yeast in the fermenter. The fermentation process is anaerobic in nature [2] . The chemical equations below summarize the fermentation of sucrose ($C_{12}H_{22}O_{11}$) into ethanol (C_2H_5OH). The overall chemical formula for alcoholic fermentation is:

$$C_6H_{12}O_6 + \text{Zymase} \rightarrow 2\ C_2H_5OH + 2\ CO_2$$

Types of Ethanol

There are many different mixtures of Ethanol that are widely used on the market today. It can be mixed in nearly any percentage depending on the gas station and the location of the station. The normal mixture of gasoline to alcohol in the ethanol is only about 10 percent corn alcohol. But there are many other mixtures, one of the common new mixtures is 85% alcohol and 15% gasoline. This is E85 which can only be run in E85 equipped engines which are only sold in newer vehicles. Almost every other vehicle is able to run on 10 percent ethanol without problem. In many Midwest areas this is less expensive than premium gas and draws more people to buy the mixtures.[3].

Table 1: Comparison between the properties of Gasoline , Ethanol and Ethanol Blend

Proprieties		Gasoline	Gasoline/Ethanol Blend	Ethanol
Mixer Air to fuel		1:14.5	1:12.7	1.9
Specific gravity(kg/m^3)		770	780	810
Heat of combustion		10.5	9.6	6.1
Octane number	MON	80	82	89
	RON	90	92	106

Table2. Kenana Ethanol production

Million Liters						
2009	2010	2011	2012	2013	2014	2015
9,215,220	413,92036,	36,178,333	32,755,171	47,079,280	38,584,376	25,198,840

Data source: Kenana *Ethanol Factories*

Environmental impacts of ethanol production

-Impact in air

Emissions from ethanol production may vary slightly depending on the process, design and feedstock. Avariety of emission control technologies are used to control potential air pollutants from ethanol plants.

volatile organic compounds (VOCs) are produced during fermentation, distillation and drying. Potential emissions of VOCs are measured and controlled through plant design regardless of the biofuel technology used. Combustion from boilers in the plant generates carbon monoxide, nitrogen oxides, and sulfur oxides[4]

-Impact in water: Because the quality of water coming into a plant can vary, it's more efficient to focus on managing and reusing the wastewater generated during the ethanol process, which is more consistent and reliable. This is typically

"Blow down" residual water from boilers and cooling towers .

Some plants are implementing creative ways to reduce water usage including use of "gray" municipal wastewater, return of water to farmers for crop irrigation, management of mineral levels in water supplies—even the development of zero-discharge technology that eliminates waste stream disposal issues altogether.

-vinasse impact

Environmental impacts from manufacture worldwide has shown that high volume release of vinasse as a wastewater directly into waterways causes discoloration o f water, strong odor, and Stalinization of fresh waterways. In extreme cases, eutrophication may temporarily occur, where the decomposition of the organic matter decreases the oxygen in the water and increases algae growth, which disrupts or harms the waterway eco system. High volume disposal of vinasse on land increases soil salinity and compaction levels, but because of the high decomposition rate of the organic matter, the components of the material do not accumulate in the soil,including NO3 and NO4. Proper disposal of the material and notification of accidental spillage is currently required in most countries [5]

-Effects on human health.

Vinasse (beet, cane) does not contain toxic chemicals, has no safety measures required by state, federal, or international regulations, and has no harmful effects on human health. The components of molasses vinasse (proteins, amino acids, carbohydrates, vitamins and minerals) are used as food, food additives, and distilled alcohol, and as ingredients in livestock feed. Vinasse has-been successfully fed to livestock worldwide for many years without adverse effects on human health.

Effects on soil organisms, crops, livestock.

Many studies exist reporting that vinasse is a good fertilizer, indicating it is potential source of organic matter and plant nutrients, especially for its P and K Values and as a soil conditioner which stimulates growth of beneficial microorganisms in the soil and allows better uptake of nutrients into the plant. Vinasse is mainly of plant origin, with some microbial residue (yeast). The components of vinasse are readily metabolized and utilized by micro-organisms as energy sources. Studies indicate that un composted cane vinasse, composted beet and cane vinasse, and cane and beet vinasse composted with raw manure or solid plant materials increases crop yield, structural stability of soils, soil microbial biomass, C-CO2 respiration rates, N cycle functioning, and enzymatic activities values, while exchangeable sodium percentage remained under critical sodicity values of about 15.In addition, when vinasse is composted with other agricultural wastes, decomposition rates increase.Studies also indicated that un composted beet vinasse in general has higher salinity rate values than cane vinasse and, when applied to soil in high volume, decreases soil physical and biological properties and crop yield [5]

II. MATRIALS AND METHODS

The following materials which were used in this study were collected from Ethanol factory (in Kenana), many analysis for different samples was mad and discussion the out put result. The samples which were taken are: Mash samples (dilution molasses 3:1) ,Beer sample taken after center fugal process to spirited yeast from Beer after fermentation , yeasted Beer sample, flagma sample (ethanol as concentration (69 -80%))

Hydrous sample (ethanol as concentration (90 -94%)), anhydrous sample(ethanol as concentration (99.7 -99.9%)), vinasses sample(by product of ethanol process).And the samples was analyzed to out put the properties and studies the result of properties .[6] [7][8].

III. RESULTANDDISSECTION

Table 3:Result test to determination Brix in fermenters

Time hours	**Fermented No.1**		**Fermented No.2**		**Fermented No.3**		**Fermented No.4**	
	Brix (9-14)	**Temp. 34C^{o}max**	**Brix (9-14)**	**Temp. 34C^{o}max**	**Brix (9-14)**	**Temp. 34C^{o}max**	**Brix (9-14)**	**Temp. 34C^{o}ma x**
0	12.56	31	12.20	31	12.38	31	12.45	31
1	12.51	31	12.18	31	12.36	31	12.24	31
2	12.61	31	12.23	31	12.60	31	12.50	31

3	12.66	31	12.20	31	12.48	31	12.42	31
4	12.60	31	12.20	31	12.30	31	12.24	31
5	12.60	31	12.19	31	12.24	31	12.21	31
6	12.10	31	12.05	31	12.19	31	12.18	31
7	12.60	31	12.10	31	12.18	31	12.12	31

fermenter5		**Fermenter6**		**Holding Tank**	
Brix (9-14)	**Temp. 34C°max**	**Brix (9-14)**	**Temp. 34C°max**	**Beer (4-8))**	**Yeasted Beer (4-8)**
12.45	31	12.99	31	7.10	12.10
12.41	31	12.94	31	7.20	7.20
12.56	31	12.89	31	7.20	7.20
12.37	31	12.67	31	7.20	7.20
12.25	31	12.54	31	7.20	7.20
12.14	31	12.51	31	7.20	7.20
12.13	31	12.20	31	7.20	7.20
11.88	31	12.13	31	7.20	7.00

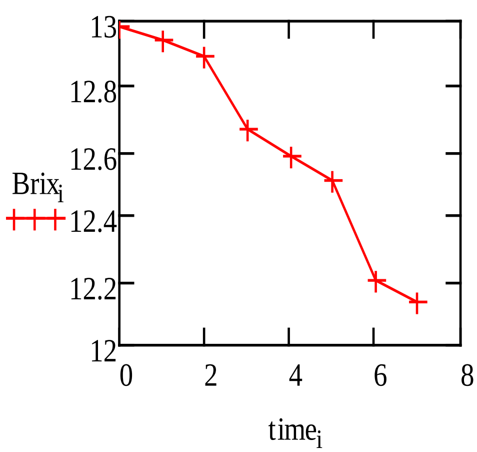


Figure1: Relation between time and Brix in fermented No.6

Table4:Result test to determination concentration ethanol and pH

Time	**Fermented No.1**		**Fermented N o.2**		**Fermented No.3**	
	Ethanol v/v (4-8)	**PH 4.5max**	**Ethanol v/v (4-8)**	**PH 4.5 max**	**Ethanol v/v (4-8)**	**pH 4.5 max**
1	**6.70**	**4.71**	**7.20**	**4.68**	**7.2**	**4.73**
2	**6.501**	**4.72**	**7.00**	**4.68**	**7.00**	**4.70**
3	**6.10**	**4.68**	**6.80**	**4.61**	**6.9**	**4.62**
4	**6.20**	**4.66**	**7.00**	**4.58**	**6.7**	**4.61**
5	**6.10**	**4.58**	**6.90**	**4.56**	**6.7**	**4.58**
6	**6.30**	**4.40**	**6.87**	**4.58**	**6.7**	**4.60**

Time	Fermented No.4		Fermented No.5		Fermented No.6	
	Ethanol v/v (4-8)	pH 4.5 max	Ethanol v/v (4-8)	PH 4.5 max	Ethanol v/v (4-8)	PH 4.5 max
1	7	4.67	7.2	4.72	6.9	4.72
2	6.9	4,67	7.1	4,70	6.9	4.72
3	6.6	4.58	6.9	4.58	6.8	4.56
4	6.9	4.56	6.9	4.56	6.9	4.54
5	7	4,53	7.0	4.53	7.2	4.54
6	6.9	4.55	7.0	4.56	7.0	4.52

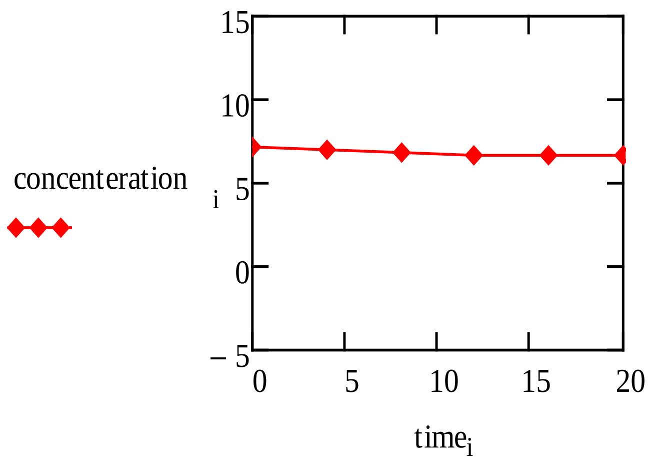


Figure2.Relation between concentration of ethanol and time in fermented No.3

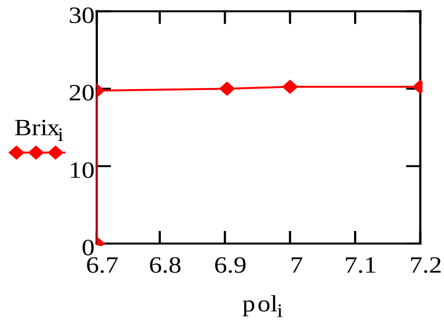
Table5:Result test to determination concentration of yeast

Time	Center Fugal				Pre Fermented	
	NO	Yeasted cream (55-70)%	Yeasted Beer (10-13)%	Beer ≤0.7	PH4 max	Brix
0	1	57	10	0.7	4.6	12.93
	2	--------			-----	----
	3	58	10	0.7	4.62	12.90
2	1	56	10	0.7	4.43	11.51
	2	----------	---------	------	------	----
	3	57	13	0.7	4.41	11.48
4	1	58	10	0.7	4.1	11.62
	2	---------	-------	-----	-----	-----
	3	56	10	0.7	4.5	11.59
6	1	55	10	0.7	4.33	11.45
	2	--------	-------	------	------	------

	3	58	10	0.7	4.52	11.52

Table6:Result to determination of(T.R.S,pol,R.S) for mash sample

Mash					**Beer Tank**		**Fermenters**		
Time	**Brix% (15-24)**	**TRS (10-13)**	**POL (6-10)**	**Purity (34-40)**	**POL 2max**	**R.S 3max**	**No.**	**POL 2max**	**R.S 3max**
0	**20.23**	**11.77**	**7.51**	**33.12**	**1.21**	**2.11**	**1**	**1.22**	**2.21**
							2	**1.26**	**2.30**
2	**20.22**	**-------**	**7.21**	**36.19**	**----**	**---**	**3**	**1.18**	**2.18**
							4	**1.24**	**2.26**
4	**19.89**	**11.71**	**7.16**	**36.77**	**1.28**	**----**	**5**	**1.28**	**2.23**
6	**19.84**	**-----**	**7.06**	**36.09**	**----**	**2.1**	**6**	**1.31**	**2.37**



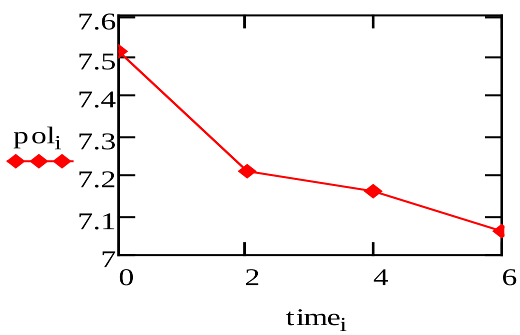


Figure2: pol and time,figure3 pol and Brix in mash sample

Table 7: Result to determination concentration of ethanol in hydrous , anhydrous, flagma, later water, vinasses

Time	Anhydrous		Hydrous	Flagma	Laterwater		Vinasses	
	Eth%w/w (99.79-99.90)	Water in Eth.(0.21) Max	Eth%w/w (90-94)	Eth%w/w (69-80)	Eth%v/v (0.02) Max	Brix% (0.25) Max	Eth%v/v (0.02) Max	Brix% (15) max
0	99.85	0.14	91.82	68.2	0.02	0.21	0.01	10.09
1	99.83	0.16	92.18	68.79	------	-------	-----	------
2	99.83	0.14	92.06	69.62	------	-------	------	------
3	99.85	0.14	92.32	70.31	-------	-------	-------	------
4	99.85	0.14	92.30	69.45	0.02	0.22	0.02	10.10
5	99.85	0.14	92.33	69.76	-------	-------	------	-------
6	99.85	0.13	92.28	69.65	-------	------	-------	------
7	99.86	0.13	92.06	70.11	-------	-------	-------	------

Table8:Result to determination of final ethanol quality

Time	Eth(w/w) (99.78-99.88)	Water Content 0.21max	PH(6.5) Max	Acidity 30max	Conductivity 0.78max	Appearance Clear, Bright
0	99.84	0.15	6.44	21.60	0.73	Clear, Bright
2						
4	99.86	0.13	6.44	21.60	0.72	Clear, Bright

Table9: Result for test to determination ethanol concentration, BOD,COD in vinases sample

Brix	**Ethanol concentration**	**BOD**	**COD**
10.30	**0.04**	**2917.9mg/L**	**18170mg/L**

Result analyses

High Brix in fermeters is undesirables because of its effect on yeast activation which lead to decrease of ethanol concentration . from the result in table3:the value of the brix in optimum range .Increasing the temperature over maximum range will affect inyeast activity inversely.If pH in the fermenter beyond the optimum degree from the result in table 3:the concentration of ethanol will decrease. During the fermentation process the pH will decrease so, Then we have change the pH media from alkaline to acidic media then yeast can produce high ethanol concentration.when there is a high ratio for the optimum rang result in table5: of polarization sugar (pol) and reducing sugars (RS) in Beer that means the yeast consumption of sugar in fermenter was not good. This high ratio of pol and RS in the beer will affect the distillation Colum (scaling) .If the quantity of final product of ethanol decrease this means high percentage of ethanol is lost and carry out in vinasses, carry out in lutter water and drain .high conductivity of ethanol refers to decrease of the quality of ethanol for uses as a fuel result in table 7:from result in table8: the value of concentration of ethanol in vinasses increase of the optimum range theses lead to increase the carry out of ethanol in by product . and if the value of the COD,BOD increase for standers it is cause pad effect of the soil.

IV. CONCLUSIONS

The sample of (mash, beer, ethanol with different composition ,vinasses) was taken from Kenana ethanol factories and analyzed and studies of the results to determined optimum comdation lead to production of the e thanol at high guilty.Also when the properties of molasses is good and high efficiency of fermentation and distillation processes theses lead quantity of final product of ethanol increase and production high concentration of ethanol.(99.8%) this means less percentage of ethanol is losses and carry out in vinasse (by product of ethanol industries) in other wise thesis good effects to decrease environ mint impact of vinasse .

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