JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

"Performance Analysis of a Solar-Powered Fuel Ethanol Distillation System using multiple chambers"

Pramod N. Wadaskar[1], Akash N. Langde[2], Narendra N. Wadaskar,[3]

Ph.D. Scholar in Mechanical Engineering, Nagpur University, Maharashtra INDIA1 Professor in Mechanical Engineering Department of Anjuman College of Engineering, Nagpur, Maharashtra, INDIA[2] Professor in Mechanical Engineering Department of Guru Nanak Institute of Technology, Nagpur, Maharashtra, INDIA [3,]

Abstract: - The utilization of solar energy for ethanol distillation presents several advantages, including reduced carbon emissions, decreased reliance on non-renewable energy sources, and potential cost savings. However, efficient conversion of solar energy into usable heat for distillation remains a challenge, necessitating innovative approaches to enhance system performance. chambers designed to optimize heat transfer within the distillation system, offer a promising solution to this challenge by increasing thermal conductivity. This study presents the performance evaluation and analysis of a solar-powered fuel ethanol distillation system by changing the parameters of multiple chambers. The system aims to harness solar energy for the distillation of fuel ethanol, contributing to renewable energy solutions and sustainable fuel production.. The performance of the system is evaluated through experimental testing and analytical modeling, considering factors such as ethanol yield, energy efficiency, and system stability. With the economic analysis, the results show that the use of solar distillation systems appear to be economical compared to the conventional distillation system using fuel oil as heat source.

Key words: Solar-powered, Fuel Ethanol, Distillation System, chambers, Performance Evaluation, Analysis, Renewable Energy, Heat Transfer Efficiency, Sustainability.

INTRODUCTIONS

Ethanol (ethyl alcohol) as a liquid fuel for cooking and lighting is an attractive alternative to kerosene in developing countries. Besides being a biomass-derived fuel and hence renewable, Ethanol can also be used in new types of cooking stoves and lanterns .Ethanol Has been traditionally produced from sugarcane, cereal grain etc.. Biogases are an excellent raw material for paper and hence it is a waste to use it as fuel. Solar distillation of ethanol does provide a solution for energy conservation in ethanol production. This paper presents the data generated for a study of pilot solar distillation plant to produce ethanol (hereafter referred to as alcohol) using sweet sorghum as the raw material. Distillation is an energy consuming process that is used for about 95% of all fluid separation in the chemical industry and accounts for an estimated 3% of the world energy consumption. Heat integration of distillation columns, where the condenser of one column is coupled with the reboiler of another column, is used to reduce the energy consumption of distillation. Typically, the reduction in energy consumption is 50%. It is very important that such heat integrated columns are operated correctly so that the plant is operational and the energy savings are achieved.

This study will focus on different distillation methods for small scale production of potable water which is suitable for domestic, small factories, laboratories, and emergency use. This review presents various technologies available for small scale distillation with focus on Refro-distiller systems. Consequently, the theoretical analysis to determine the efficiency and energy costs are presented.

© 2**OBJECTIVE:**

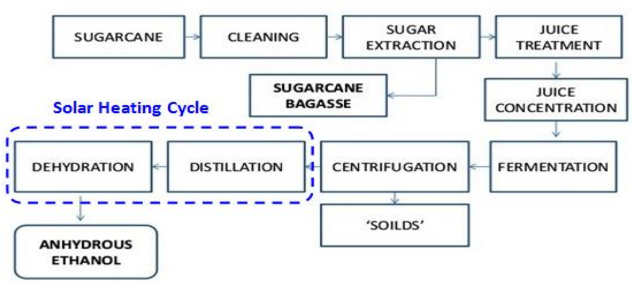
- To study the feasibility of solar energy powered fuel ethanol production process.
- To reduce the cost of ethanol production.
- To create new opportunities for small businesses in rural areas.
- To reduce the pollution due to distillation of ethanol

This research work is carried out the conventional ethanol production process consist of following steps-

.

.

to return to earth as



evaporates it (salts rainwater

Figure 1: Processes involved in production of ethanol and solar heating cycle

The present research work focuses on "**Distillation**" steps of this process.

The modification and improvement shall be restricted to this part of this process only.

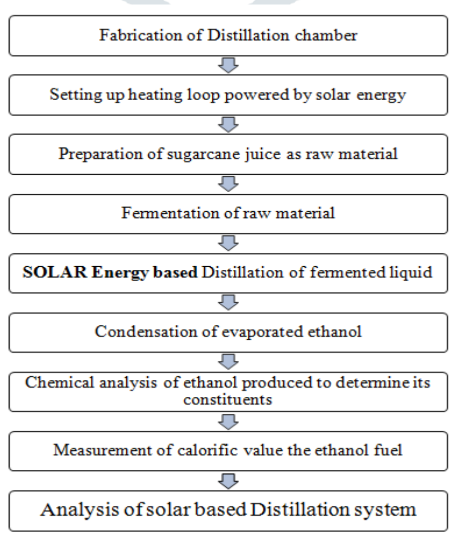


Figure 1: Flow diagram showing steps involved in Ethanol production in present research work

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWING

This invention will now be described in relation to the accompanying drawing, in which figure 3 illustrates Line diagram of powered ethanol production system

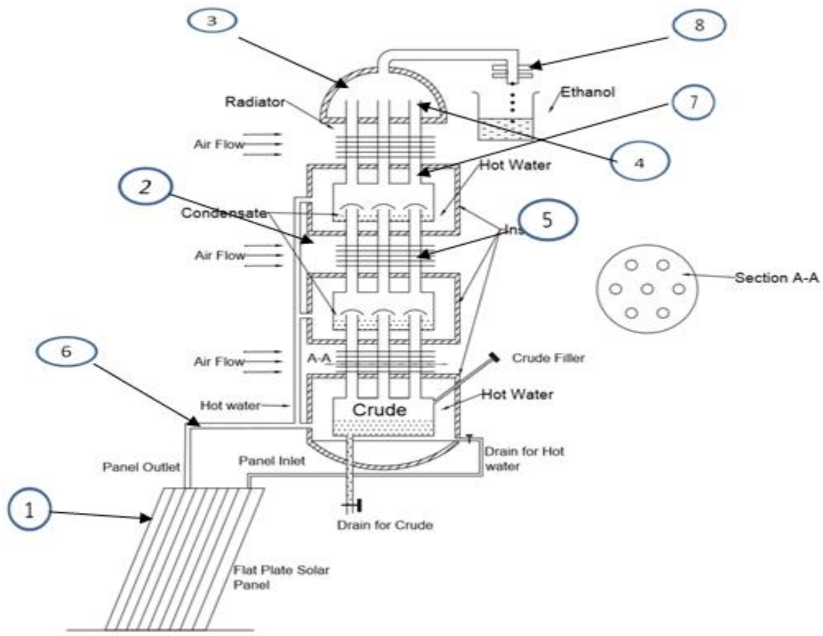


Figure 2: Schematic arrangement of solar powered ethanol production system.

DETAILED DESCRIPTION OF THE ACCOMPANYING DRAWING

The arrangement of solar powered ethanol production system is simple in construction and mainly it consists of some primary parts which may be considered as the working elements and various auxiliary parts for its proper functioning and for providing stability. Each unit (parts) has its own importance in the assembly of solar powered ethanol production system. The working of these units is to study the feasibility of solar energy powered fuel ethanol production process and to reduce the pollution due to distillation of ethanol The assembly of solar powered ethanol production system consist of following units: -

1) Flat Plate solar panel
2) Shell and tube Heat Exchanger
3) Tank
4) Digital Temperature Indicator
5) Copper Tube
6) Pipes
7) Thermocouple
8) Tap

FIELD OF THE INVENTION:

This invention related to design and fabrication of solar powered distillation system. The conventional distillation system for distillation consumes around 40-50 % of energy produced. To produce one fuel (Ethanol) another fuel is burned which result in consumption of lot of energy in Ethanol production. Also, consumption of conventional fuel result in large pollution to form and also will increase its cost. The proposed work would be able to produce Ethanol fuel without consumption of conventional fuel by using solar energy. The fabrication will have an arrangement of multistage distillation in single distillation column. The distillation column will have alternate arrangement of heating of fermented wash and condensation of vapors formed for more than 95 per of ethanol. The heating will be provided by water, heated by solar energy. Temperature sensors will be provided in distillation column at heating chambers which will allow heated water to flow at pre-determined temperature. After design and fabrication of the system experimentation will be carried out. The performance of the system and chemical analysis of ethanol will be carried out.

EXPERIMENTAL DESIGN

In order to achieve the optimum results, the design of this project has been broadly divided into 2 major sections followed by the sub-sections. The 2 major sections in this project are the Solar Heating Section & the Ethanol Distillation Unit.

Figure: 4. Solar water heating section

The Solar Heating Section:

The heating section is the area where complete heating of water takes place in order to maintain high temperature in the water jackets. The unit comprises of three major components.

1. Solar Tubes
2. Drum
3. Frame

1.Solar Tubes: In order to make our project as eco-friendly as possible we used solar water tubes as they are completely pollution free and requires next to zero maintenance cost. For our project we used 2 solar tubes in order to meet our requirements.

2. Drum: We used Aluminum to make the drum in order to keep it light weight and durable. The capacity of the drum is approximately 20-25 liters. The complete drum is surrounded by a thick layer of 'Glass Wool' material to create a good insulation effect to keep the temperature of water in the drum as high as possible. Also, there are two ports for inlet and outlet of water in the drum.

3. Frame: The complete frame setup has been made up of Mild Steel material. The drum is attached on top of the frame at 3ft height of the ground in order to provide proper pressure head to the water to fill in the water jackets. The frame is designed to firmly support the drum as well as the solar tubes without any fiddling or movement. Also, a pipe is connected in between the heating section and the distillation unit to transfer the hot water.

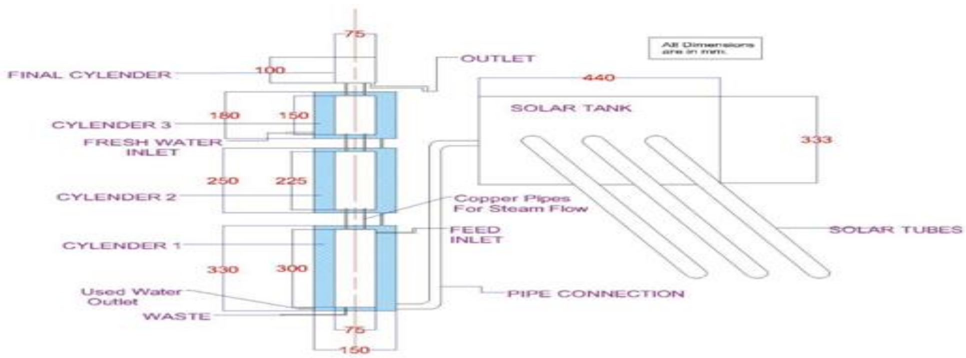


Figure 5: Line diagram of the project

Figure: 6. Distillation Unit

II- Ethanol Distillation Unit:

The complete unit serves the purpose of distillation of Ethanol. It comprises of several small components which are connected in a sequential manner to get the best results.

1. Water Jackets.
2. Molasses Cylinders.
3. Copper Tubes.
4. Temperature Indicator.
5. Water, Waste, Feed, Ethanol Inlet & Outlet tube.

1. Water Jackets: A total of three water jackets have been created around the main 3 cylinders. The water jackets are made of Mild Steel and have also been completely insulated by using Glass wool in order to maintain the high temperature. The three cylinders are connected to each other by copper tubes for the flow of water from one cylinder to the other.

2. Molasses Cylinder: There are three cylinders made of copper placed inside the water jacket and the last one is kept open to the atmosphere. The fermented molasses is first poured in the bottom most cylinders and then by distillation the final product is obtained in the last cylinder. The capacity of each cylinder decreases respectively from bottom to top as the waste product remains in the bottom cylinder as the refined product moves forward.

3. Copper Tubes: Copper tubes have been attached to every cylinder in order to create a flow of molasses from bottom cylinder to the top cylinder. The gap between two cylinders is connected by a set of 4 copper tubes each of diameter 5 mm and length of 5cm.

4. Temperature Indicator: A temperature indicator has been provided at the top water jacket. It is a necessary component to keep the water temperature in the last cylinder at around 77.5-79 deg Celsius. A fresh water inlet has also been provided to bring down the temperature in case it exceeds the required temperature.

5. Inlet & Outlet tubes for various purposes: Multiple small tubes have been provided to perform specific functions like Feed Inlet, Waste Extraction, Final product outlet etc.

Sr.no	$C1=L_{C1}/D_{C1}$	Atmosperic Temp(°C)	To (Water Temp at inlet) (°C)	Ti (Water Temp at Outlet) (°C)	Temp Difference (To -Ti)	Ethanol Capacity Lit/Day
1	177.8/203.2	30	82.5	75	7.5	32.1
2	228.6/203.2	35	83.5	75.1	8.4	32.27
3	254/203.2	34	87.6	77.8	9.8	321.5133
4	279.4/203.2	40	99.8	86.3	13.5	32.768
5	304.8/203.2	37	102.7	87	15.7	33.0233

TABLE 1

Sr.no	$C2=L_{C2}/D_{C}$	Atmosperic Temp(°C)	To (Water Temp at inlet) (°C)	Ti (Water Temp at Outlet) (°C)	Temp Difference (To -Ti)	Ethanol Capacity Lit/Day
1	127/152.4	30	82.7	75	7.7	33.024
2	177.8/152.4	32	83.6	75.3	8.3	33.1923
3	203.2/152.4	34	88	78.1	9.9	33.4443
4	228.6/152.4	40	100	86.3	13.7	33.6963
5	279.4/152.4	37	102.9	87	15.9	33.9483

TABLE 2

Sr.no	C3=L_{C3}/D_C	Atmosperic Temp(°C)	To (Water Temp at inlet) (°C)	Ti (Water Temp at Outlet) (°C)	Temp Difference (To -Ti)	Ethanol Capacity Lit/Day
1	76.2/101.6	30	82.6	74.8	7.8	34.1163
2	127/101.6	32	83.4	75.3	8.1	34.21
3	152.4/101.6	34	88	78	10	34.3409
4	177.8/101.6	40	100.1	86.3	13.8	34.4814
5	228.6/101.6	37	103	87.1	15.9	34.6219

TABLE 3

Sr.no	C1=LC/D_{C1}	Atmosperic Temp(°C)	To (Water Temp at inlet) (°C)	Ti (Water Temp at Outlet) (°C)	Temp Difference (To -Ti)	Ethanol Capacity Lit/Day
1	254/152.4	30	83	87.1	7.9	35.9567
2	254/177.8	32	84	75.1	8.5	36.2167
3	254/203.2	34	95.1	75.5	10	36.6067
4	254/228,6	40	100.3	85	13.7	36.9967
5	254/254	37	103	86.3	16	37.3867

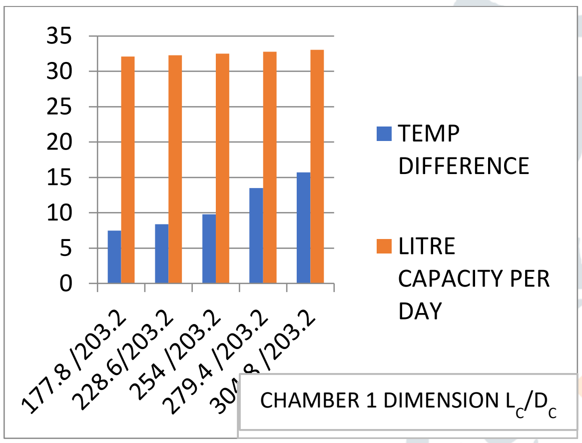
TABLE 4

Sr.no	C2=L_C/D_{C2}	Atmosperic Temp(°C)	To (Water Temp at inlet) (°C)	Ti (Water Temp at Outlet) (°C)	Temp Difference (To -Ti)	Ethanol Capacity Lit/Day
1	203.2/76.2	30	83	75	8	37.2567
2	203.2/127	32	84	75.4	8.6	37.5167
3	203.2/152.4	34	95.1	84.8	10.3	37.9067
4	203.2/177.8	40	100.3	86.3	14	38.2967
5	203.2/203.2	37	103	86.9	16.1	38.6867

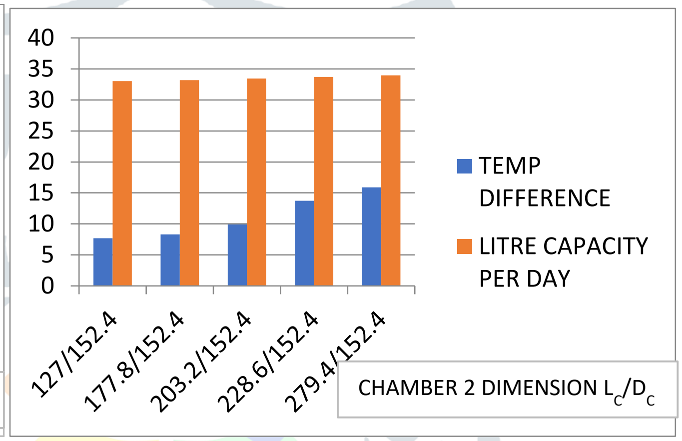
TABLE 5

Sr.no	$C3=L_C/D_{C3}$	Atmosperic Temp(°C)	To (Water Temp at inlet) (°C)	Ti (Water Temp at Outlet) (°C)	Temp Difference (To -Ti)	Ethanol Capacity Lit/Day
1	152.4/50.8	30	83	75	8	34.1163
2	152.4/76.2	33	83.6	75.3	8.3	33.2763
3	152.4/101.6	34	89	78	11	34.3878
4	152.4/127	40	100	86.3	13.7	37.1267
5	152.4/152.4	38	102.9	87	15.9	38.8167

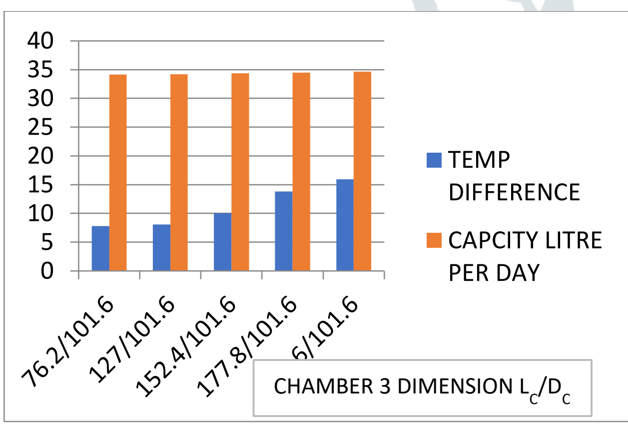
TABLE 6



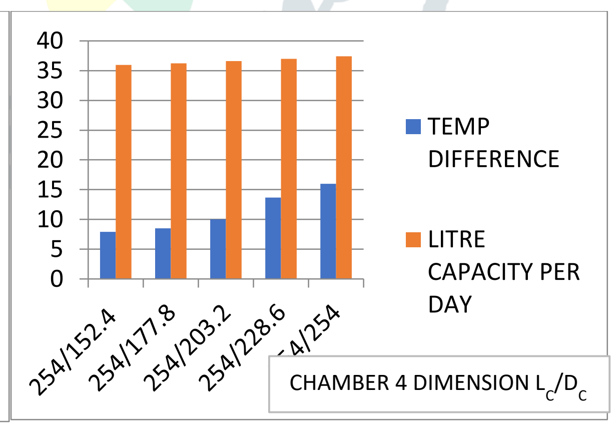
GRAPH 1



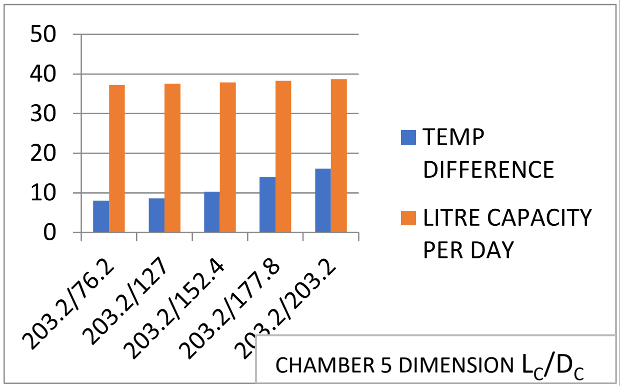
GRAPH 2



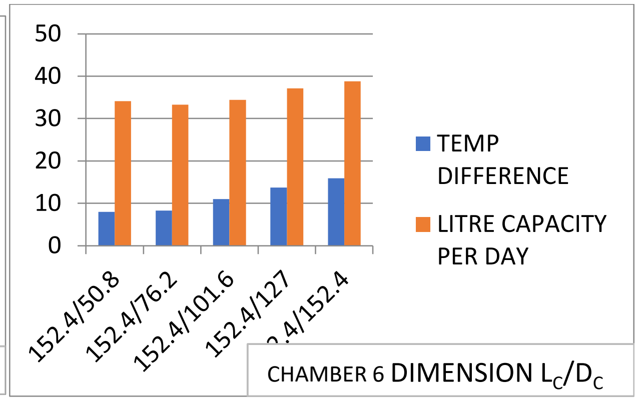
GRAPH 3



GRAPH 4



GRAPH 5



GRAPH 6

NOMENVLATURE:

L_C= LENGTH OF CHAMBER IN MM

D_C= DIAMETER OF CHAMBER IN MM

REFERENCES

I] Katzen, R., Madson P.W and Moon, G.D. (1999) Ethanol distillation: the fundamentals, KATZEN International, Inc., Cincinnati, Ohio, USA.

II] Jorapur, R. & Rajvanshi, A. (1991). Alcohol distillation by solar energy, ISES Solar World Congress Proceedings, Vol. I, Part II, pp. 772-777, Denver, Colorado, USA, August 19-21, 1991.

III] Vorayos, N, Vorayos, N and Kiatsiriroat, T (2003) Experimental Investigation of Ethanol Distillation System with Different Types of Solar Collectors, Destination Renewables- ANZSES 2003.

IV] Vorayos, N. and Kiatsiriroat, T. (2006) Technical Note - Performance analysis of solar ethanol distillation, Renewable Energy, Volume 31, Issue 15, December 2006, Pages 2543–2554, doi: 10.1016/j.renene.2006.01.016.

V] Hewitt, G.; Quarini, J. & Morell, M. (1999). More Efficient Distillation. The Chemical Engineer, 21st October 1999.

VI] Braisher, M.; Gill, S.; Treharne, W.; Wallace, M. & Winterburn, J. (2006). Design Proposal: Bio-ethanol Production Plant. 15.02.2007, Available from http://www.ethanol.org
.

VI] Shawaqfeh A.T. and Farid M.M (1995) Distillation of Ethanol in a Solar Still: Studies on Heat and Mass Transfer, J. Sol. Energy Eng 117(3), 236241 doi:10.1115/1.2847809.

VIII] Toure, S., Salami, H. and Meukam, P. (1999) Theoretical and experimental studies of a solar still type suitable for alcoholic distillation, Renewable Energy Volume 16, Issues 1–4, January–April 1999, Pages 739–742 http://dx.doi.org/10.1016/S0960-1481(98)00268-7.

IX] Namprakai, P. and Hirunlabh, J. (2007) Theoretical and experimental studies of an ethanol basin solar still, Energy, Volume 32, Issue 12, December 2007, Pages 2376–2384.

X] Schrier, J. (2012) Ethanol concentration by forward osmosis with solar regenerated draw solution Solar Energy, Volume 86, Issue 5, May 2012, Pages 1351–1358, doi: 10.1016/j.solener.2012.01.027.