Multi-Nozzle Jet Spray Condenser Design and Analysis using MATLAB

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Abstract— A multi-nozzle jet spray condenser has been designed and analyzed to fulfill the requirements of vacuum problem in Sugar & pharmaceutical industries. This design and analysis has been done for Sugar unit of Armstrong Infrastructure Pvt. Ltd. A single jet condenser has been using by this industry which gives an efficiency of around 59%. To overcome this multi-nozzle jet spray condenser has been used which gives around 20% more efficiency compared to single jet. MATLAB software has been used to design the multi-nozzle jet spray condenser and to find out the vacuum generated. Data has been taken from the sugar section of the industry, and analysis has been carried out to find out the suitable condenser capacity design and performance evaluation.

Key words: Multi-Nozzle Jet Spray Condenser, Sugar Can, MATLAB

I. Introduction

The fundamental strong deposits from sugar and ethanol creation are sugarcane bagasse and sugarcane rubbish, moreover named as sugarcane agriculture residues (SCAR). Sugarcane bagasse is the sinewy waste that remaining parts after the recuperation of sugar juice through pounding and extraction. It additionally has been the key fuel utilized the world over as a part of the sugarcane agro-industry due to its energy properties. The presentation of sugarcane harvesting joined with technical enhancements has enriched the cogeneration in sugar also, ethanol manufacturing plants. This improvement has occurred amid the recent decades of the twentieth century, and it has changed drastically the perspective on the utilization of residuals in the sugarcane agro-industry.

Sugarcane (Saccharum officinarum) is the world's biggest cash crop. There are more than 90 sugar-producing nations around the globe. Particularly for underdeveloped nations, sugarcane residue removals have first-order need. The world's sugarcane generation has tested a sensational development amid the most recent decade shown in figure 1. The world sugarcane agro-industry has handled more than 1685 × 10^6 tons in 2010. The said measure of sugarcane created 23.6 × 10^6 tons of bagasse (dry basis) and same measure of SCAR. The energy substance of both residues could be equal to around 85 × 10^6 tons of oil. In a different way one can say that the sugarcane agro-industry produces around 660 kg of strong residues for each milled ton of stick (wet basis).

Among the sugarcane-creating nations, Brazil, today the world's pioneer in the utilization of renewable energies when all is said in done, in bioenergy specifically, plays an exceptional part in this field. The Brazilian sugarcane agribusiness improvement is an effective reference which could be replicable halfway or altered by numerous sugarcane producing nations. Brazil has the most created what's more, incorporated biofuel program on the planet. It is an undeniable certainty that Brazilian fluid biofuels are most understood over the world. The bioethanol that originates from sugarcane is particularly critical.

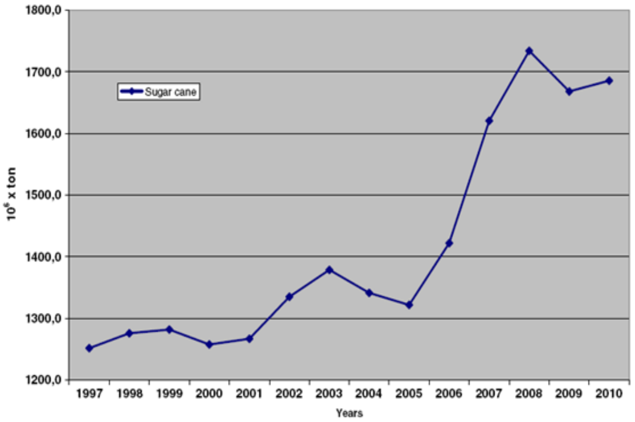


Fig. 1: World sugarcane production 1997-2010[1]

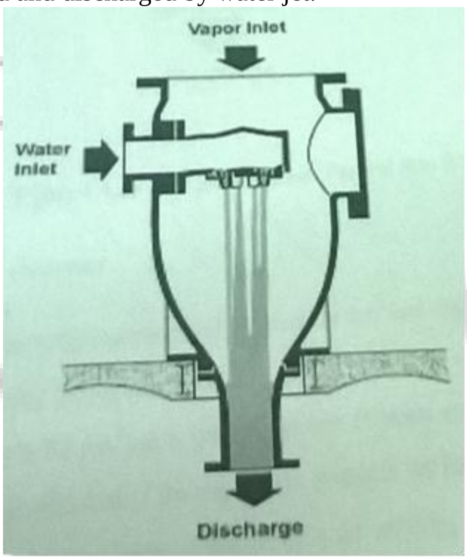
From a specialized and efficient perspective, it is less expensive and less demanding to deliver ethanol from sugarcane than from corn. The ethanol from sugarcane delivered in Brazil is three to four times less expensive than the bioethanol from corn delivered in the USA.d keeping in mind the end goal to create ethanol from corn, an extra step is vital in the creation process. The starch of corn ought to be changed over to sugar before the maturation, while in the instance of sugarcane; the sugar for maturation is contained straightforwardly in the sugarcane juice. This point of interest of ethanol from sugarcane is truly an open door for immature sugarcane-creating nations to differentiate the sugarcane business through the presentation of new sugarcane by-items, for example, fuel bioethanol and other sugarcane derivate. Be that as it may, the generation of fuel bioethanol from sugarcane juice contends with the generation of sugar, other nourishment items, and solutions.

This in addition to different components, for example, issues concerning nursery gas (GHG) emanations, the ascent of oil cost in the universal business sector, and other geopolitical variables connected with customary oil supply precariousness, are empowering the second's presentation era biofuels as another open door acquired from biomass deposits and lignocellulose biomass. This new pattern ought to be considered amid the modernization of the sugar business or for vitality arranging by organizations and governments. The fundamental motivation to consider the creation of second-era bioethanol is that, as it was at that point specified, 66% of the residues of sugarcane are lignocellulose. In the light of second-era bioethanol generation surplus sugarcane bagasse could be utilized to create bioethanol or to create surplus power. The utilization of bagasse for second-era bioethanol generation, rather than its customary utilization as fuel for cogeneration in the sugar processing plant, has raised some new worries on its conceivable substitute. Despite the fact that SCAR vitality utilization is still minute in the Brazilian sugar processing plants, it is by all accounts that SCAR ought to be the bagasse's substitute for cogeneration in the sugar processing plant.

The fundamental point of this paper is to do an appraisal on the bagasse and SCAR accessibility and their vitality utilization in the sugarcane agro-industry. The exchange off on sugarcane bagasse vitality use (power cogeneration versus bioethanol creation), considering the agro-modern advancement level, is investigated, as well. The better choices for every situation are highlighted. The primary ecological and techno economic angles concerning the sugarcane agro-industry were considered amid the appraisal process. The most encouraging patterns of the sugarcane agro-industry what's more, the hindrances that ought to be overcome in its usage are pointed out.

II. ASSEMBLY OF SINGLE-JET NOZZLE CONDENSER

Condensing water is delivered into the jet case and ejected through the jet. These are carefully designed to handle a specific amount of water at stated pressure and guaranteed vacuum. The water jet is directed into the tail piece at lower end of body, where they unite to form a single jet. Vapors entering condenser comes into direct contact with converging water then condensed. Non-condensable are also entrained and discharged by water jet.



(a) Low level jet condenser

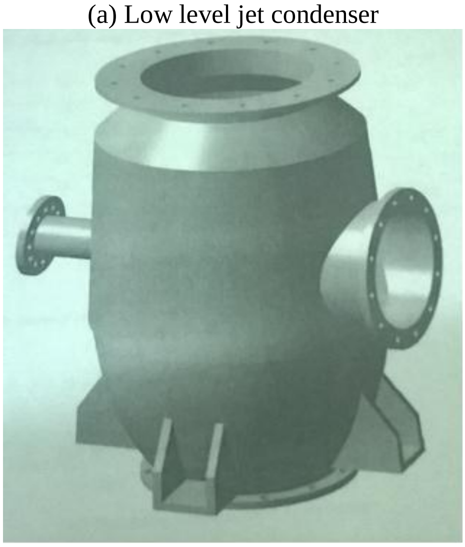

(b) Designed using software

Fig. 2: Low level jet condensers (Counter Flow Type)

A. Advantages of Multi Nozzle Jet Condenser

- Mixing of steam and cooling water is better.
- Multi nozzle jet spray condenser having two main components nozzle and jet requires for spraying the water over vapour due to this we get maximum area of contact hence maximum heat transfer rate compared to single jet condenser.
- In multi-nozzle jet spray condenser the vapour comes in contact with the water particle in two stages in first stage vapour get condensed by water spray through nozzle in the second stage partly condensed vapour comes in contact with the water spray by multi jet in the centre of condenser and complete vapour conversion into water takes place.
- For better quality crystallization and refining of sugar in the sugar pan required maximum vacuum area, sugar quality depends on the maximum condenser efficiency that can be achieved by using multi-nozzle jet condenser.
- Maximum condenser efficiency and vacuum efficiency get increased.

III. PERFORMANCE EVALUATION

A. Condenser Efficiency

It is the ratio of rise in temperature of cooling water to the difference between saturation temperature of steam and inlet temperature of cooling water.

$$\text{Condenser efficiency} = \frac{\text{Rise in temperature of cooling water}}{\left(\begin{array}{c}\text{Temperature corresponding to vacuum in} \\ \text{condenser - Inlet temperature of cooling water}\end{array}\right)}$$

$$\eta_c = \frac{T_a - T_i}{T_s - T_i}$$

Where,

T_a=Temperature of outgoing water from condenser
T_i=Inlet cooling water temperature to condenser
T_s=Saturation temperature at condenser pressure

B. Vacuum Efficiency

The lowest pressure or highest vacuum which can exist in the condenser is the saturation pressure of the steam corresponding to steam temperature entering into the condenser. But the actual pressure in the condenser is always greater than the ideal pressure by an amount.

$$\text{Vacuum efficiency} = \frac{\text{Actual vacuum in the conderser}}{\text{Ideal vacuum in the condenser}}$$

$$\eta_v = \frac{P_b - P_t}{P_b - P_i}$$

Where,

P_b=Barometric pressure
P_i=Absolute ideal vacuum
P_t=Absolute total vacuum

IV. ANALYSIS AND RESULTS

Using a MATLAB code value of vacuum has been determined and a graph of related values has been represented on a graph shown below.

Different values of time have been selected.

For example: 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120 and 130.

Results from the table have been plotted on a graph shown in figure 3.

Time (seconds)	Vacuum (inches)
10	1.18
20	2.79
30	4.62
40	6.60
50	8.70
60	10.91
70	13.21
80	15.59
90	18.04
100	20.57
110	23.14
120	25.78
130	28.47

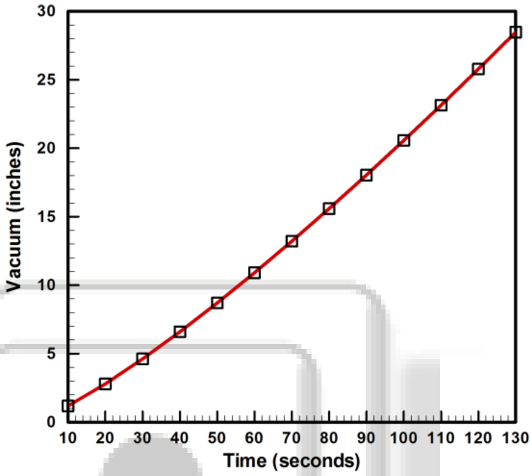


Fig. 3: Graph Vacuum Time

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