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EFFECTIVE UTILIZATION OF SUGAR INDUSTRY WASTE FOR BIO- ETHANOL PRODUCTION

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ABSTRACT

Energy crises are widespread particularly in developing countries like Pakistan. Available fuel resources are decreasing day by day causing a remarkable increase in the cost of fuel. Each year Pakistan spends a huge amount of money to import fuel to meet its energy requirements. The need to develop alternate fuel resources is the demand of the day. Studies show that Ethanol can be used as an alternative energy source. Pure Ethanol and mixture of ethanol with other fuels is used in vehicle as fuel in many countries of the world. The paper describes a process to produce ethanol using sugar molasses and yeast as the raw material. Sugar molasses is the waste of the sugar industry after sugar production. Ethanol is produced from sugar molasses through fermentation. Lab scale Unit is designed and fabricated to perform the experiments and find the effect of various parameters like temperature, dissolved oxygen, mixing effect, PH. Keeping PH between 4.8 to 5, temperature between 30 °C–37°C, stirrer speed 150 RPM were found to show the maximum productivity.

Key Words Ethanol, Fermentation, Molasses, Saacharomyces cerevisiea.sugar industry waste

INTRODUCTION

Energy crises are widespread particularly in developing countries like Pakistan while the modern world fuel demand is increasing day by day. Fuel Resources present in Pakistan are limited and is on the verge of depletion. The energy requirements of Pakistan are mostly fulfilled by importing the fuel which is causing a huge strain on the economy of the country. All these factors along with others are boosting the cost of fuel with the passage of time. Hence the need to search for the alternative fuel resources is inevitable. The production of environmentally friendly bio-ethanol is possibly one of the solutions to the problem. Pure Ethanol and ethanol –gasoline (10:90 or 10:20 ratio) blend can be used a transportation fuel [Error! Reference source not found.]. No change in car engine is required for 10:90 ethanol gasoline blend .Ethanol is an environmentally friendly fuel as it produces less harmful gases on burning [Error! Reference source not found.]. Ethanol mixed with gasoline increases the octane number of the gasoline so it can replace the lead additives in fuel as lead is highly hazardous and causes air pollution [Error! Reference source not found.]. Ethanol is produced from sugar, starches and cellulose through fermentation by yeast .The most effective and inexpensive strain of yeast used for fermentation is Saacharomyces Cerevisiea also known as Baker's yeast [Error! Reference source not found.].

Several attempts have been made previously to improve the production of ethanol. Using finger millet flour in ethanol fermentation from sugar increases the yield of ethanol and reduces fermentation time . Paper sludge can be used as an effective raw material for ethanol production after mechanical crushing and tenderness by chemicals Error! Reference source not found.. Kitchen garbage is converted to ethanol by using acid tolerant bacteria Error! Reference source not found..

Sugar molasses is the most important raw material that can be used for ethanol production Error! Reference source not found.. Molasses is a cheap source of raw material as it is the waste of sugar industry also it contains nutrients that accelerate the fermentation process Error! Reference source not found..

In this work laboratory scale unit has been designed for the production of ethanol from sugar molasses and various parameters like PH, Dissolved oxygen, Temperature, Mixing effect have been investigated.

EXPERIMENTAL SETUP

Laboratory scale experimental unit is designed to produce ethanol from sugar molasses. The purpose of the experimental unit is to study the effect of various parameters on ethanol yield and provide a basis for larger scale set up for ethanol production. The complete view of the unit designed for ethanol production is shown in **Error! Reference source not found.**

Figure 1 here

The unit consists of the following components

- Reactor
- Stirrer
- Water Tanks
- Pump (centrifugal pump)
- Heater
- Copper tubes
- PH meter
- Oxygen meter
- Wood stand

Reactor

This is the main part where fermentation occurs. Acrylic glass cylinder is used as a batch reactor with a height of 16 inches, outer diameter of 8 inches and an inner diameter of 7.75 inches. The capacity of the reactor is 7 liters. Acrylic glass cylinder was selected because it is transparent and can withstand high temperature. The head of the cylinder has ports for a thermometer, air inlet, electric motor for stirrer, PH meter, oxygen meter, hot water inlet and outlet

Figure 2 here

Stirrer

Stirrer is used for proper mixing of the reactants to maximize the conversion. Stirrer consists of stir bar with an impeller diameter of 3/4 inches .Stir bar spins by an electric motor. A 12 volt DC motor is used for this purpose. An adapter is used for converting AC current to DC for the motor.

Figure 3 here

Water Tanks

Temperature is maintained in the reactor through hot water circulation Two Water tanks are used for circulating hot water in the reactor one for the inflow and other for the outflow. The tanks are connected to one another through pipes and ball valve.

Figure 4 here

Pump

A centrifugal pump is used for pumping hot water from water tanks to the reactor.

Figure 5 here

Heater

The electric rod heater is used in the water tank which supplies hot water to the reactor.

Copper tubes

Hot water flows in copper tubes in the reactor for heat transfer between hot water and the reactants.

Figure 6 here

PH Meter

PH meter is used to measure the PH of the Process.

Figure 7 here

Oxygen Meter

The dissolved Oxygen is measured in the process through an Oxygen meter**.**

Figure 8

Wood Stand

Wooden stand is used to assemble all the parts of the unit.

Figure 9 here

Process Description

The raw materials used in experimental unit were sugar molasses and yeast. Molasses is the by-product obtained from the processing of sugar cane into sugar. The strain of yeast selected was Saacharomyces Cerevisiea and the sugar molasses was collected from Muree Breweries industry Pakistan. Molasses selected was found to contain 40% sugar. The raw materials were inserted in the batch reactor and they were allowed to react for 72 hours for the complete conversion of molasses to ethanol. The sugar molasses react by the process of fermentation in the presence of yeast to produce ethanol and carbon dioxide by the following reaction.

$$C_6H_{12}O_6 \xrightarrow{\text{yeast enzyme}} 2C_2H_5OH + 2CO_2$$

The temperature, PH, stirrer speed and dissolved oxygen were measured during the reaction. The concentration of the ethanol obtained from the reaction was measured by refractometer which measures the concentration with the help of the refractive index of the solution. A simplified flow sheet of the process is shown in Figure 10.

To study the effect of various parameters on ethanol production temperature, PH and stirrer speed were varied one by one and the optimum conditions for maximum yield were identified. The temperature of process was maintained through the heat transfer between hot water flowing in the copper tubes and the raw material. The water was transported from the water tank to the copper tube through centrifugal pump. Hot water entered the reactor from the first water tank, circulated inside the copper tube and leaves from the other end of the second water tank as shown in Figure 11 and Figure 12. The two tanks were connected through the pipe and ball valve so that the water can be reused. A bypass valve from the exit of the first tank to its entrance allows the reheat of the water if needed. PH of the process was maintained by adding acid or base to the reactants. Mixing, PH and temperature effects on the process were studied by varying these parameters. A complete unit design and process flow sheet is shown in Figure 11 and Figure 12.

Figure 10, Figure 11 and Figure 12 here

RESULTS AND DISCUSSION

The three parameters selected i.e. Temperature, pH and mixing effect were changed one by one and their effects were studied. Figure 13, Figure 14 and Figure 15 shows the effect of these parameters on the ethanol production. The ethanol concentration increases with increase in temperature till 30 °C and then increases steadily till 37°C, after 37°C the concentration of ethanol starts decreasing rapidly. This is because the yeast enzyme ceases their activity at higher temperatures. Similarly it can also be seen from Figure 14 that maximum ethanol is produced in the PH range of 4.8 to 5 further increasing the PH reduces the ethanol production. Hence the microbes use maximum sugar in slightly acidic medium. Mixing slightly increases the productivity at 150 -155 RPM**.**

Figure 13 **and** Figure 14 **here**

CONCLUSIONS

A lab scale unit was designed for the ethanol production from sugar molasses. The design was found to be relatively simple and provides a basis for larger scale set up of ethanol production. The raw material used was the byproduct of the sugar industry, hence an effective method for utilization of the waste was carried out on lab scale for producing ethanol. The experiments showed that the maximum ethanol concentration was achieved at PH 4.8-5, temperature 30°C–37°C, stirrer speed of 150 RPM.

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Figure 1 Experimental Unit for ethanol Production

Figure 2 Reactor

Figure 3 Stirrer with accessories

Figure 4 Water Tanks

Figure 5 Centrifugal Pump

Figure 6 Copper Tubes

Figure 7 PH Meter

Figure 8 Oxygen Meter

Figure 9 Wood Stand

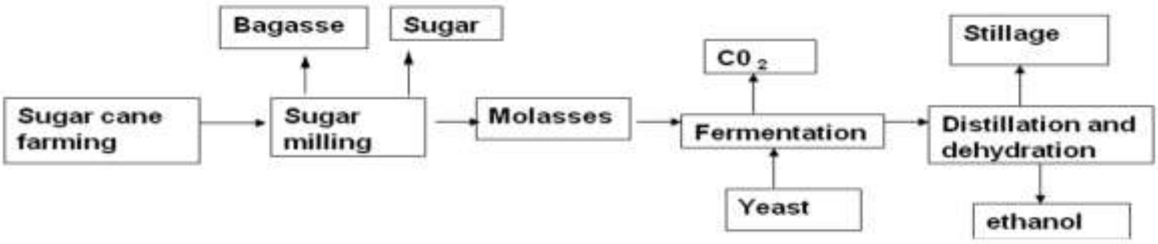

Figure 10 flow diagram of the ethanol production process

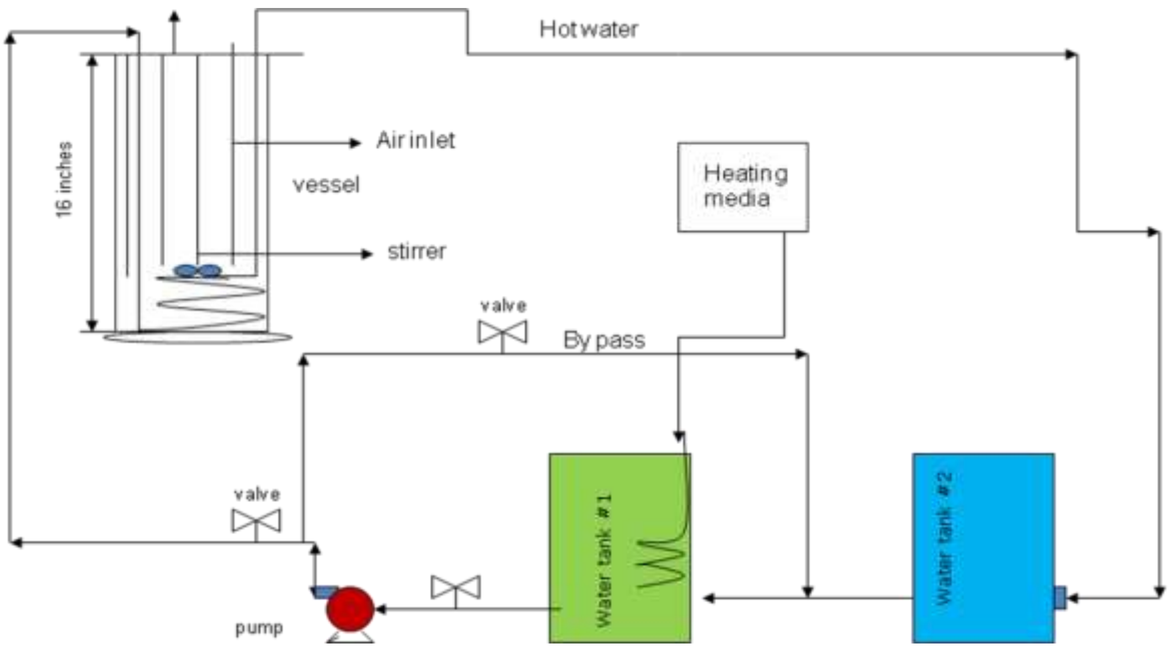

Figure 11 Flow diagram of the Experimental Unit

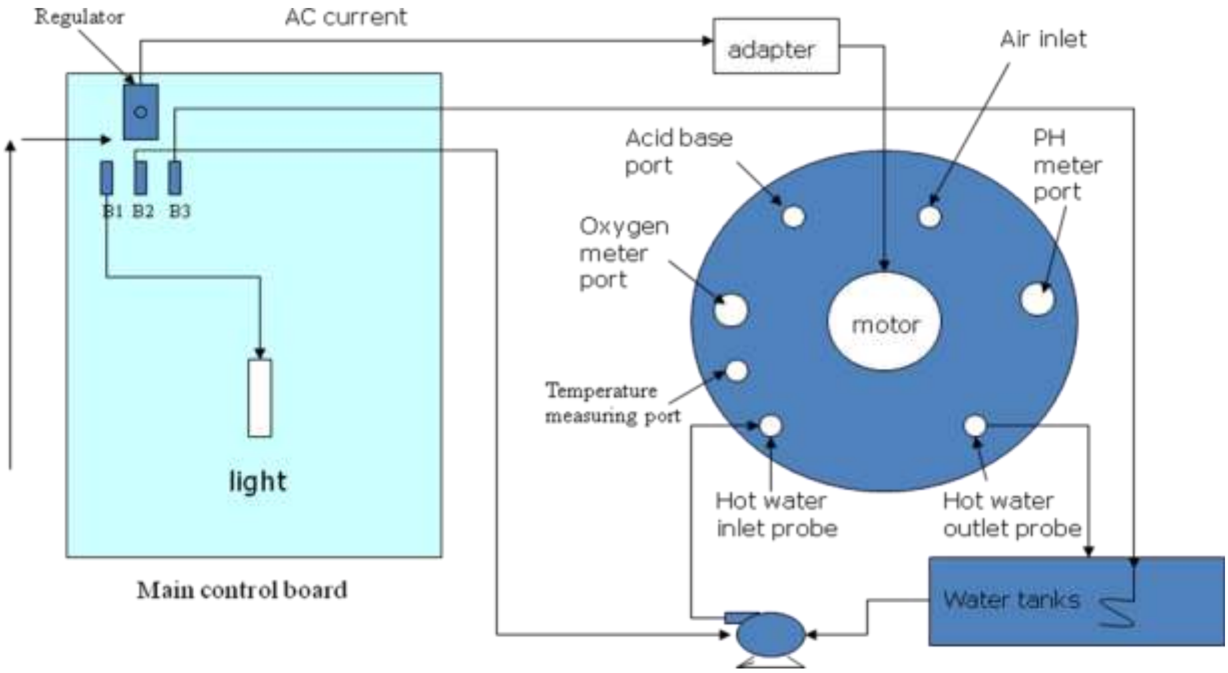

Figure 12 Top view of the unit

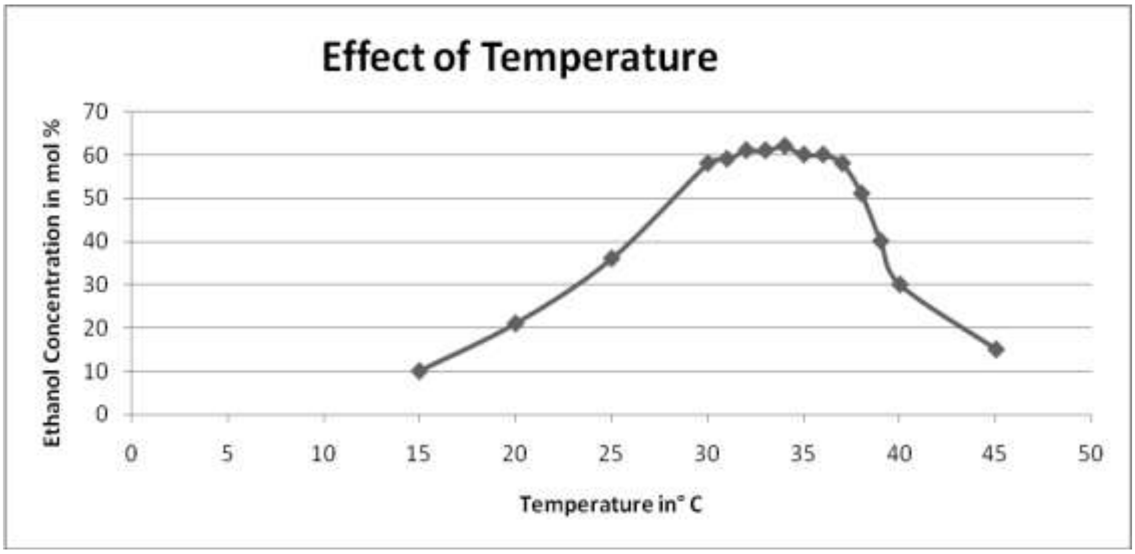

Figure 13 Temperature effect

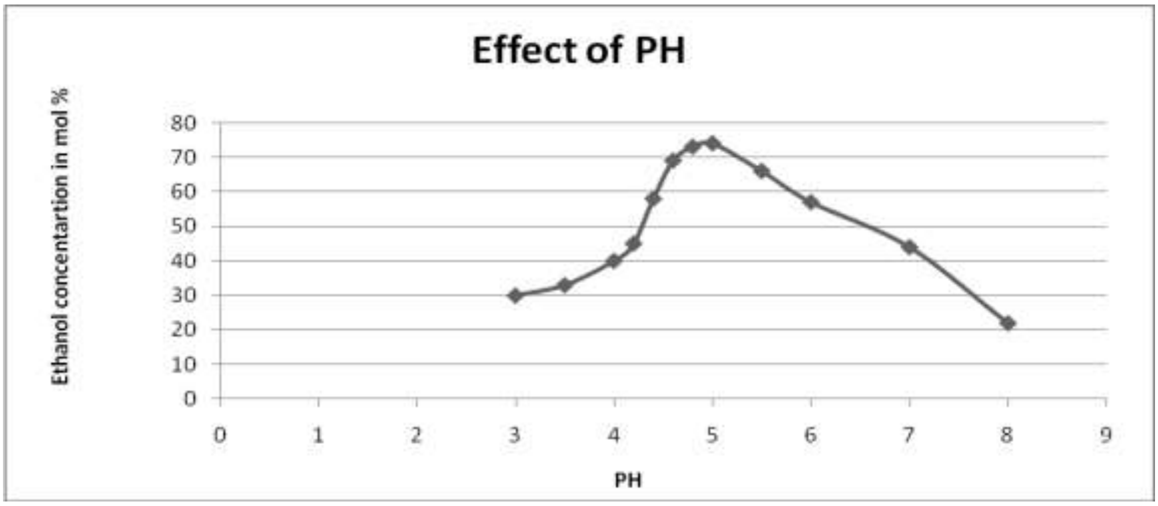

Figure 14 PH Effect

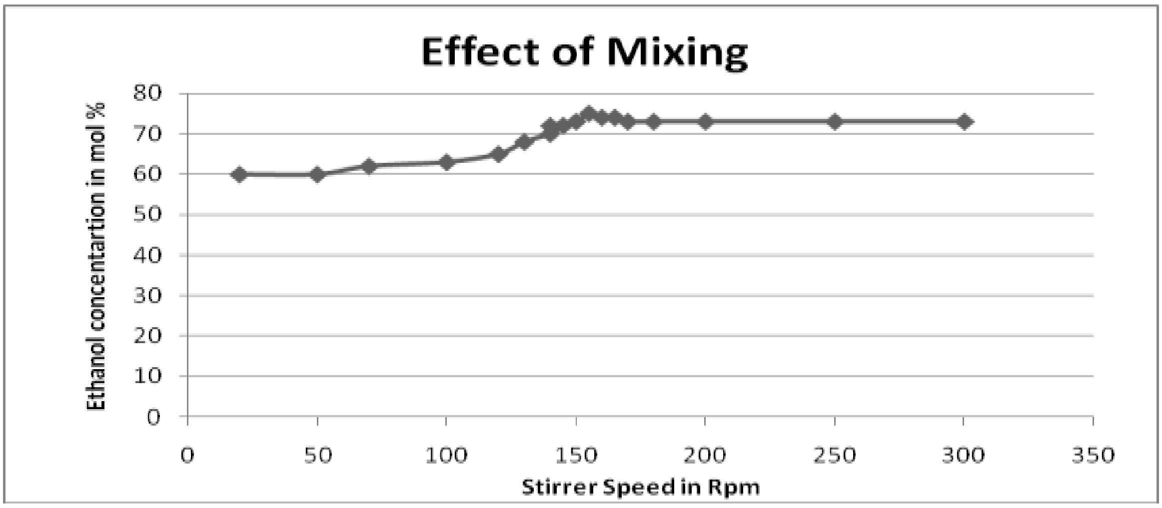

Figure 15 Mixing Effect