By-Products

TREATMENT OF ALCOHOL DISTILLERY EFFLUENT USING SUGARCANE PITH

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Key words: Pith, bagasse, vinasse

ABSTRACT

A method is discussed for alcohol distillery effluent treatment using sugarcane pith to be combined with vinasse so that it can be burnt in the conventional boilers of the sugar factory. The method is based on the fact that pith can absorb more than five times its own weight of vinasse without draining. When one part of pith is mixed with one part of vinasse, the mixture contains 70% moisture. This can be reduced to 50% by using 53% of the flue gases from the boilers of the sugar factory at 250°C in a pneumatic transport drier. The dried mixture of pith-vinasse can be burned in the conventional boilers of the sugar factory. The calorific value of the solids in vinasse is the same as that of bagasse and they contribute heat that is equal to 15% of the heat liberated by the bagasse producing steam in excess of the distillery requirements. The ash from the boiler is rich in potassium and can be used as fertilizer. The proposed method solves entirely the problem of pollution by stillage, and the net value of the heat from the solids in vinasse, plus the fertilizer value of the ash, exceeds the net profit obtained from the alcohol produced by the distillery.

INTRODUCTION

Alcohol distilleries have to dispose of 12 parts of stillage for each part of alcohol produced. Because stillage has a high organic matter content, it has a high BOD of about 40 000 to 60 000 ppm. When stillage is dumped into streams and rivers, the oxygen in the water is exhausted and fish life is damaged. The water becomes undrinkable due to its colour, taste and odour.

There are several methods for alcohol distillery effluent treatment, but large investments in equipment are required and the cost of processing is high (Kuiala). The method proposed here is extremely simple and requires only standard sugar industry equipment. The costs of raw materials and energy are very low because the raw materials are all waste products (vinasse, pith and flue gases), and the electrical power needed amounts only to 1.86% of the fuel value of the solids recovered from the vinasse. At the same time the ash can be used as fertilizer because of its high potassium content, or as a raw material to produce potassium hydroxide to replace sodium hydroxide.

MATERIALS AND METHODS

In the sugar process, 100 kg of sugarcane produces 15 kg of pith and 4 kg of molasses which produces 1.1 litres of alcohol and 12 kg of vinasse in the distillery. The vinasse contains 1.06 kg of solids that produce 0.94 kg of ash when burnt. Pith is made up of the soft, thin wall, irregularly shaped parenchymatous cells of the inner stalk tissue of sugarcane. It can absorb more than five times its own weight of vinasse without draining. When 15 parts of pith are mixed with 12 parts of vinasse, the resulting mixture contains 70% moisture, and only 27% of the full absorptive capacity of the pith is used. The flue gases from the boilers of the sugar factory at temperatures between 180 and 300°C, are more than sufficient to evaporate the water in the vinasse. The stillage contains solids in solution which have a calorific value of 4 090 kcal/kg or 1 831 kcal/kg at 50% moisture.
The proposed process consists of mixing the pith from a sugar factory or an independent distillery with the stillage from the distillery. The pith-vinasse mixture is dried using flue gases from the sugar factory to reduce the moisture content of the mixture to a level equal to or less than that of the pith before treatment. The dried mixture of pith and vinasse is burned in conventional boilers of a sugar factory, the heat liberated by the solids in vinasse producing an amount of steam surplus to the requirements of the distillery. In this way the need for expensive boilers or other equipment to burn the liquid vinasse is avoided. Not only does the process eliminate pollution due to stillage disposal and preserve the ecology, but it also causes the smoke and particles of unburnt bagasse to be entrapped in the pith-vinasse drier. These are then burned together with the pith-vinasse mixture, increasing the calorific value of the fuel by 2.5%.

**PROCESS**

Bagasse from the sugar mill is sent to a rotary sieve with a wire cloth screen (1) to separate the pith (see Fig 1). The pith is then mixed with the vinasse (6) in the mixer (2), the vinasse having previously been neutralised with milk of lime in the distillery. The moist mixture of pith and vinasse from the mixer is fed into the drier (3) which is heated by flue gases from the boiler (4) and impelled by a fan (5) to a cyclone (7) where the dried pith vinasse mixture is discharged onto a bagasse conveyor that feeds the boilers.

![Diagram illustrating pith/vinasse mixing process](image-url)

Figure 1. Diagram illustrating pith/vinasse mixing process
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The sieve is the same as that used in the bagasse fibre board industry to separate pith from the bagasse. It is a rotary drum, 2 m in diameter and 6 m long with a wire cloth screen. This sieve delivers 30 tons of 6 mm mesh pith per hour when the bagasse comes from a mill without a shredder. With a 10 mm mesh 46 tons of pith can be obtained per hour. With bagasse from a mill with a shredder, the output is 50 tons of 6 mm mesh pith or 57 tons of 10 mm mesh pith per hour. The sieve runs at 17 rpm, has an inclination of 13° and is driven by a 45 HP electrical motor.

The mixer is a screw type conveyor with the spiral cut many times along its length so that it acts as a mixer.

A pneumatic transport drier is used. This is simplest kind of drier and it is suited to the small size of the particles and high range of moisture contents (70 to 50%). The power consumed is less than 4 KW/ton of pith. The flue gases needed to evaporate the water from the vinasse comprise 53% of the total flue gases from the boilers of the sugar factory. The remaining flue gases are more than enough to dry the bagasse from the mill from 53% to 35% moisture on a dry basis.

Boilers used to burn the pith-vinasse mixture are the standard boilers used in the sugar-cane industry. Boiler efficiency when burning pith-vinasse will be higher than when burning bagasse because of the small size of the particles (hence less excess air), more CO₂ in the flue gases, and higher temperatures in the furnace.

MASS AND HEAT BALANCE

Assume a distillery attached to a sugar factory making alcohol from molasses. 100 kg of sugarcane gives 30 kg of bagasse, 15 kg of pith and 4 kg of molasses, which in the distillery produces 1.1 litres of alcohol and 13 kg of vinasse containing 1.06 kg of solids that when burnt produce 0.94 kg of ash.

Ratio pith: vinasse = 1 : 0.86, or approximately 1 : 1

Water to be evaporated:

Pith goes into and out of the drier at 50% moisture. Solids in the vinasse (Brazil) = 8.15%. Solids at 50% moisture = 16.3%. Amount of solids from the vinasse = 13 kg × 16.3% = 2.12 kg. Water to be evaporated: 13 kg vinasse - 2.12 kg of solids = 10.88 kg.

Amount of water that can be evaporated with the flue gases at 250°C from the combustion of the total bagasse:

30 kg bagasse × 1800 kcal/kg × 0.204(a) × 0.95 (b)/547 kcal/kg (c) = 19.13 kg

Amount of water that can be evaporated with the flue gases at 250°C from the combustion of the solids of vinasse:

2.12 kg × 1800 kcal/kg × 0.204 × 0.95 (b)/547 = 1.35 kg

Amount of water that can be evaporated with flue gases:

19.13 + 1.35 = 20.48 kg

Amount of flue gases used in the drier to evaporate 20.48 kg of water, 30 kg of bagasse is needed. To evaporate 10.88 kg of water 15.93 kg of bagasse is needed = 53%. Steam that can be produced from the combustion of the solids in the vinasse:

2.12 kg solids × 1800 kcal/kg × 0.80 (d)/547 (e) = 5.58 kg steam consumption of the distillery : 3 kg/litre of alcohol.

Steam surplus: 5.58 kg - 3 kg = 2.58 kg = 46.2%

(a) heat lost in the flue gases (Hugot⁴)
(b) drier efficiency (Abilio⁵)
(c) assuming a vinasse temperature of 90°C
(d) boiler efficiency
(e) assuming a feed water temperature of 90°C
BY-PRODUCTS

Alcohol from mixto.  
100 kg of sugarcane give 30 kg of bagasse; 15 kg of pith; 5 kg of sugar for the distillery; 2.75 litres of alcohol; 33 sf of vinasse.  
Ratio pith: vinasse = 1 : 2.2 or approximately 1 : 2.  
Water to be evaporated: Pith goes into and out of the drier at 50% moisture.  
Solids in the vinasse (Brazil): 5.27%  
Solids in the vinasse at 50% moisture: 10.54%  
Amount of solids from the vinasse: 33 kg vinasse × 10.54% = 3.48 kg  
Water to be evaporated: 33 kg vinasse - 3.48 kg solids = 29.52 kg  
Amount of water that can be evaporated by flue gases at 250ºC from the combustion of bagasse: 19.13 kg  
Amount of water that can be evaporated by flue gases at 250ºC from the combustion of the solids in vinasse = 3.48 kg × 1800 × 0.204 × 0.95/547 = 2.22 kg.  
Amount of water that can be evaporated by the combustion of the solids in vinasse = 3.48 kg × 1800 × 0.8/547 = 9.16 kg  
Amount of water evaporated: 19.13 + 2.22 + 9.16 = 30.51 kg.  
Steam consumption of the distillery: 2.75 litres alcohol × 3 kg steam/kg = 8.25 kg.  
Steam surplus: 30.51 - 29.52 = 1 kg = 12.12%  
Independent distillery. Alcohol from cane juice. Alcohol production: 120 000 liters per day  
Basic data:  
Surplus bagasse: 11.1 ton/h  
Pith available: 12.7 ton/h. Vinasse produced: 60 ton/h. Solids in vinasse: 2.37%. Amount of solids from vinasse at 50% moisture: 2.86 ton/h  
Ratio pith: vinasse = 1 : 4.7.  
This ratio is too high for a transport drier, so it is proposed to evaporate the vinasse partially in a double effect evaporator at atmospheric pressure and to dry the mixture of pith and concentrated vinasse in the conventional manner. The surplus bagasse, 11.1 ton/h is used for the production of high pressure steam (21 kg/cm² at 270ºC) for power generation, 1400 KW, and the exhaust steam, 20 ton/h can be used in the evaporator.  
Mass and heat balance:  
Exhaust steam: 20 ton/h  
Amount of water that can be evaporated in double effect: 40 ton/h  
Amount of solids from the vinasse: 2.86 ton/h. Concentrated vinasse: 20 ton/h  
Amount of water to be evaporated: 20 - 2.86 = 17.14 ton/h  
Amount of water that can be evaporated by flue gases at 250ºC from the combustion of bagasse:  
25.4 ton/h × 1800 × 0.204 × 0.95/547 = 16.2 ton/h  
Idem from the flue gases from the combustion of the solids in vinasse: 1.82 ton/h  
Amount of water evaporated by flue gases: 16.2 + 1.82 = 18 ton/h  
The drier: pith available: 12.7 ton/h. Concentrated vinasse: 20 ton/h  
Ratio pith: vinasse = 1 : 1.6  
Amount of steam produced by the combustion of the solids in vinasse: 2.8 ton/h solids × 1800 × 0.8/547 = 7.37 ton/h = 49.13% of the steam consumed by the distillery.  

MELTING POINT OF THE ASH

Ash content in pith = 4.9%; in vinasse = 2.9%; in 1 : 1 pith-vinasse mixture = 3.9%.  
Amount of ash from vinasse in the ash from pith-vinasse: 36%. Amount of ash from vinasse if the ash from pith-vinasse is mixed with the total bagasse of the sugar factory: 22%.  

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Melting point of ash from 1:1 pith-vinasse in mixture:

Melting temperature of ash depends on its content of anions and cations according the following ratio (Paturau):

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\frac{SiO_2 + Al_2O_3}{Fe_2O_3 + CaO + MgO + Na_2 + K_2O}
\]

From ratios between 2.0 and 3.5, the melting point of bagasse varies from 1210 to 1350°C (Hugot).

Ash from vinasse has a high K2O content and is very low in SiO2 + Al2O3; hence it has a low melting point of about 850°C.

On the other hand, ash from pith has a low K2O content and a high content of SiO2 + Al2O3; hence it has a high melting point of about 1330°C.

Ash from a 1:1 pith-vinasse mixture has a melting point of 1130°C, and if pith-vinasse is blended with the total bagasse of the sugar factory, the melting point of the resulting ash is 1200°C.

Ash from pith-vinasse as fertilizer

All the nutrients present in the vinasse are present in its ash. The main nutrient in the ash from pith-vinasse is K2O.

The amount of K2O in ash from pith is 10.32%; from vinasse is 47% and from 1:1 pith-vinasse is 28.33%.

Amount of fertilizer to transport

The amount of ash from pith-vinasse to be transported in order to supply the same amount of nutrient as vinasse is: from molasses 4.3%; from mixto 1.7% and from juice 0.7%.

If vinasse diluted in a ratio vinasse-water 1:14 is used, the amount of ash to be transported is: from molasses 0.3%; from mixto 0.12% and from juice 0.05%.

Organic matter:

Ash from pith-vinasse as fertilizer does not have organic matter. When vinasse is applied to soils a surface film prevents the organic matter from being incorporated. Sugarcane itself supplies large amounts of organic matter from the roots of the harvested stalks (Dillewijn, Fogliata). This amount is five times the amount that can be incorporated from vinasse. When the stubble of sugarcane is incorporated with the soil every five years, it represents 25 times the amount of organic matter that can be incorporated from vinasse. If it were necessary, the trash could be incorporated into the soil to supply nine times the organic matter that can be incorporated from vinasse. Filter cake incorporates 2.5 times more organic matter than vinasse.

Ash from pith-vinasse: a raw material for producing potassium hydroxide.

Potassium hydroxide can be obtained from the ash of pith-vinasse using the same process as is used in the paper industry for recovering NaOH from the black liquor. This process is simple and has the following steps:

(a) dissolve the ash in water, (b) precipitate calcium carbonate from the solution by adding milk of lime, (c) separate the calcium carbonate by decantation, (d) recover the supernatant. This solution is a mixture of 75% KOH and 25% NaOH. The amount of KOH plus NaOH that can be obtained is 47% of the ash. KOH is a stronger alkali than NaOH and can be used in the chemical industry. In the sugar industry it can be used for bagasse paper making or for the alkaline treatment of bagasse for animal feed.

ECONOMICS OF THE PRODUCT

Solids from vinasse as fuel

For each litre of alcohol produced by the distillery, there is produced 1 kg of solids (4090 kcal/kg dry basis) or 2 kg at 50% moisture (1831 kcal/kg), equivalent to 0.36 kg of
fuel-oil or 0.40 m³ of gas. As already mentioned, the profit from the solids as fuel constitutes net profit. Taking a price of 100 US dollars/ton of fuel-oil, for a distillery producing 50,000 litres/day, the net profit from the solids of the vinasse would be 1760 US dollars/day.

**Ash as fertilizer**

Ash from the 1 : 1 pith-vinasse mixture contains 28.33% K₂O. A distillery of 50,000 litres/day produces 46.8 ton/day of ash, from which can be obtained 13.2 tons of K₂O per day. At a price of 780 US dollars/ton of K₂O, there is a gross profit of 5280 US dollars/day.

**Ash as a raw material for KOH production**

A distillery of 50,000 litres/day produces 46.8 tons of ash/day from which can be obtained 22 tons of a mixture containing 75% KOH and 25% NaOH. Taking the price of NaOH at 400 US dollars/ton, the gross profit is 8800 US dollars/day.

**COST OF THE EQUIPMENT**

The cost of the equipment for the treatment of the vinasse from a distillery of 50,000 litres/day, is about US dollars 250,000, depending on the size of the fan that is installed in the boiler. The time required to fund the capital from the fuel value of the solids in the vinasse is 4.7 months. Taking into account the ash as fertilizer, the time is 2 months if there is a 50% net profit from K₂O. If the ash is used for KOH production and taking 50% net profit, the time is 1.3 months.

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**TRAITEMENT DE L’EFFLUENT DE DISTILLERIE D’ALCOOL PAR L’USAGE DE LA MOELLE DE BAGASSE DE CANNE À SUCRE**

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**EXtrait**

Ce travail aborde une méthode de traitement d’effluent de distillerie d’alcool par l’usage de moelle de bagasse de canne à sucre comme support de vinasse afin qu’elle soit brûlée dans des fourneaux conventionnels de fabriques sucrières.
La base de la méthode est le fait que la moëlle possède un grand pouvoir d'absorption, pouvant absorber plus de cinq fois son propre poids de vinasse sans drainage. En mélangeant une partie de moëlle et une de vinasse, on obtient un mélange à 70% d'humidité, avec une réduction possible de 50% en utilisant 53% de gaz de cheminée à 250°C provenant de fourneaux de la fabrique de sucre avec séchage de transport pneumatique. Le mélange se moëlle-vinasse est brûlé dans des fourneaux conventionnels de la fabrique de sucre. La valeur calorifique des solides de vinasse est la même que celle de la bagasse et, en brûlant le mélange moëlle-vinasse, la chaleur libéré par les solides de vinasse égale 15% de la bagasse qui est capable de brûler dans le fourneau, produisant une quantité de vapeur supérieure aux exigences de la distillerie. Les cendres provenant du fourneau sont engrais riches en potassium et peuvent être employées comme engrais. La méthode proposée résoud les problèmes de pollution découlant de la distillation à 100% et le profit net provenant de la valeur du chauffage du solide de vinasse, plus la valeur de l'engrais à base de cendres, dépasse le profit net obtenu.

TRATAMIENTO DE EFLUENTE DE DESTILERIAS DE ALCOHOL UTILIZANDO MEDULA DE CAÑA DE AZUCAR

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RESUMEN
El trabajo de refiere a un método para el tratamiento de efluentes de destilerías de alcohol utilizando medula de caña de azúcar como soporte para poder quemarla en las calderas convencionales del ingenio azucarero. El método se fundamenta en el gran poder absorbente de la medula que puede absorber más de cinco veces su propio peso de vinaza sin escurrir. Mezclando una parte de medula con una parte de vinaza, la mezcla tiene 70% de humedad la que puede ser reducida hasta 50% usando el 53% de los gases de combustión a 250°C de las calderas del ingenio en un secador de transporte neumático. La mezcla medula-vinaza secada es quemada en las calderas convencionales del ingenio. El poder calorífico de los solidos de la vinaza es el mismo que el de la bagaza tal modo que quemando la mezcla medula-vinaza, el calor liberado de los solidos de la vinaza equivale al 15% de la bagaza que puede quemar la caldera y es capaz de producir una cantidad de vapor que sobrepasa los requerimientos de la destilería. Las cenizas que se obtienen de quemar la mezcla medula-vinaza, son ricas en potasio y pueden usarse como fertilizante. El método propuesto salva los problemas de contaminación de las aguas del medio ambiente en un 100% y las ganancias que se obtienen con el valor combustible de los solidos de la vinaza mas el de la ceniza como fertilizante, sobrepasa a la ganancia de la venta del alcohol de la destilería.