STEAM ECONOMY IN DISTILLERY WASTE DISPOSAL
INVOLVING SPENT WASH CONCENTRATION THROUGH
AN INTEGRATED HEAT CYCLE

A. R. Patil and J. T. Jadhav
Deccan Sugar Institute, Pune, India

ABSTRACT

For eliminating the pollution hazard caused by spent wash of fermentation distilleries, various methods have been briefly described. Of these, the one which consists of neutralizing the spentwash and concentrating it in a multiple effect evaporator followed by a single effect finishing pan to about 80° brix, and then mixing it with bagacillo or dried press-mud from the sugar factory and using it as solid potash-rich fertilizer, has been adopted.

In the system so far suggested which involve concentration of the effluent, the steam consumption for evaporation, even in multiple effects in addition to that required for distillation, is so high that the entire system becomes economically prohibitive.

A novel heat cycle now suggested by the authors and described in detail in this paper, reduces the total steam consumption so substantially that the above system of spent wash disposal becomes commercially profitable.

INTRODUCTION

In India, there are at present 119 distilleries with an annual capacity of about 667,200 KL of ethyl alcohol from waste molasses of cane sugar factories. The disposal of distillery waste has posed a serious problem due to its high load of organic matter, dark color and high inorganic salts content. The spent-wash discharged from such distilleries varies from 16 to 18 liters per liter of alcohol. The B.O.D. value of this effluent is 50,000 PPM which is about 120 times that of domestic sewage. The inorganic salt content is 10-12% on 100% solids of the spent-wash. The high B.O.D. value is injurious to aquatic life whereas the high salt content affects the soil constituents adversely damaging plant life.
A typical analysis (Chaterjee) of the spent-wash from an Indian cane molasses distillery is as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Unit</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>4.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td></td>
<td>1.02</td>
<td>1.04</td>
</tr>
<tr>
<td>Brix</td>
<td></td>
<td>8.5°</td>
<td>10.5°</td>
</tr>
<tr>
<td>Reducing sugars%</td>
<td></td>
<td>1.0</td>
<td>1.20</td>
</tr>
<tr>
<td>Sulphated Ash %</td>
<td></td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Dry matter %</td>
<td></td>
<td>9.0</td>
<td>11.0</td>
</tr>
<tr>
<td>Carbonated Ash %</td>
<td></td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Silica (SiO₂) %</td>
<td></td>
<td>0.1</td>
<td>0.15</td>
</tr>
<tr>
<td>R₂O₃ (Al₂O₃ + Fe₂O₃) %</td>
<td></td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>CaO %</td>
<td></td>
<td>0.20</td>
<td>0.50</td>
</tr>
<tr>
<td>MgO %</td>
<td></td>
<td>0.30</td>
<td>0.40</td>
</tr>
<tr>
<td>P₂O₅ %</td>
<td></td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>K₂O %</td>
<td></td>
<td>0.70</td>
<td>1.20</td>
</tr>
<tr>
<td>N₂ %</td>
<td></td>
<td>0.12</td>
<td>0.20</td>
</tr>
<tr>
<td>SO₄ %</td>
<td></td>
<td>0.80</td>
<td>0.85</td>
</tr>
<tr>
<td>Carbon %</td>
<td></td>
<td>30.00</td>
<td>34.00</td>
</tr>
<tr>
<td>Hydrogen %</td>
<td></td>
<td>2.50</td>
<td>3.00</td>
</tr>
<tr>
<td>Sulphur %</td>
<td></td>
<td>0.70</td>
<td>0.80</td>
</tr>
<tr>
<td>Oxygen %</td>
<td></td>
<td>20.00</td>
<td>24.00</td>
</tr>
<tr>
<td>Chloride %</td>
<td></td>
<td>0.45</td>
<td>0.60</td>
</tr>
</tbody>
</table>

The organic matters present in the waste are almost entirely bio-degradable and yield methane gas if subjected to anaerobic digestion by methane forming bacteria. Among the other constituents present in the effluent, the most important is potash which is a valuable ingredient of soil fertilizers.

The various methods suggested for the disposal of spent wash, therefore, primarily aims at removing the pollution hazard but some of them have incorporated systems for the recovery of methane and potash.

a) Lagooning followed by discharge into barren fields or flooded rivers. This is the cheapest method but the smell emanating from the lagoons due to decomposition of organic matter is obnoxious and is a source of great nuisance to neighboring human habitation.

In this method of disposal a large area of land is blocked which could otherwise be used for agricultural purposes. In certain cases such a large area is required for the lagoons may not be available. If the soil around the lagoons is porous in nature, the effluent may seep into neighboring water sources making the water harmful for human consumption or for aquatic life.
b) Lagooning in deep trenches in which (i) the anaerobic digestion is carried out by methane forming bacteria. The methane evolved is brought down to almost 10 percent of the original value. The remaining B.O.D. value can be further reduced to permissible standards by dilution with water, (ii) the anaerobic digestion may be carried out by ammonifying and nitrifying bacteria.

These are the next cheapest methods involving much less lagooning area, but the requirement of dilution water is still quite large, and some smell nuisance also persists. The seepage problem is also associated with both these methods.

c) Digesting the effluent in a treatment plant anaerobically with mesophilic or thermophilic methane producing bacteria, the methane produced being collected and used for fuel purposes. The treated effluent is utilized for irrigation after dilution so as to reduce the salt content. It has not been possible to adopt this method in India due to very high costs involved in the installation of methane production and utilization plants.

d) Concentrating the spent wash in a multiple effect evaporator to about 80° Brix and then incinerating it, heat is being generated utilizing it in a waste heat boiler for producing steam which can be recycled for use in the evaporator for concentration purposes. A part of the ash produced can be used for neutralizing the spent-wash and the remaining ash can be applied to the fields as potash rich fertilizer.

In this method it is anticipated that it would be difficult to obtain uninterrupted incineration of concentrated spent wash. Furthermore a waste heat boiler specifically suited for the purpose is not available. There is also some potash loss due to volatilization.

e) Concentrating the spent wash to about 80° Brix in steam heated multiple effect evaporator. If the spent wash is first neutralized with lime an evaporator with mild steel body and tubes is suitable but if the spent wash is used near the evaporator tubes and body will have to be of stainless steel. The concentrated spent-wash is then mixed with (a) solid nitrogenous and phosphatic fertilizers to obtain press-mud, obtained from the attached sugar factory, producing a potash rich solid fertilizer.

The methods (d) and (e) not only effect total elimination of the pollution hazard but are particularly suited to an agricultural country like India in view of the recovery of potash which is in perpetual short supply.

The last named method suggested by the Deccan Sugar Institute in which
the concentrated spent-wash is mixed with bagacillo or press mud (which are by products of the sugar factory) is considered to be the best as the organic matter of the bagacillo and the manural constituents of the press-mud would be additionally beneficial to the soil. This system however, involves the use of steam for concentrating the spent wash in addition to that required for distillation purposes. The total cost of steam is the major cost of this system and influences its economic feasibility. With a view to reducing this cost, a heat cycle has now been evolved which reduces the total steam consumption to such a low figure that the system becomes substantially economical.

This new integrated heat cycle, for which patent rights have been applied for, is explained below and illustrated in Fig. 1.

THE NEW HEAT CYCLE

Steam is generated in a boiler (1.2) at 10-21 bar and passed through a thermo-compressor (2) to compress vapor from the first effect (4) of a triple effect reverse feed pressure evaporator. The vapor which is at 2.95 bar is compressed to 3.85 bar and is then fed to the calandria of the first effect through a desuperheater (3). The vapor from the last effect (4.2) which is at 1.47 bar is bled to the distillation column of the distillery.

A turbo alternator exhausting at 3.85 bar could also be installed depending upon the economies of by-product power generation. In that case it would be necessary to increase one effect and discard the thermo-compressor.

The material of construction of the evaporator body is mild steel and the tubes of the calandria are also mild steel ERW tubes. With partial neutralization of the spent-wash up to pH 6.0, and taking care that the pH never goes above 8.5, the material of construction of the evaporator bodies and calandria tubes can be aluminum-magnesium alloy. The higher cost of aluminum alloy as compared to that of mild steel would be offset by substantially reduced consumption of lime and the lower cost of staging structure required for the evaporator.

The spent-wash emerging out of the distillation column is collected in a closed receiving tank (5) at a temperature of 378°K is neutralized by lime in an in-line blender (8) to pH 7.0. About 5 g of lime are required per liter of spent-wash, the lime slaked in hot spent-wash in the lime preparation equipment (7). The neutralized spent-wash is fed into the last effect (4.2) and is pumped from body to body up to the first effect (4) from where the concentrated spent-wash at 55-60° Brix is directly fed into the single effect finishing pan (9).

The condensates after flashing from body to body and in the flash tank (10.2) for finishing pan is pumped (11) through the feed wash heater (12) to heat the feed wash going to the distillation column from 328°K to 348°K.
FIGURE 1. Economic heat cycle for spent wash concentration
The condensate emerging from the feed wash heater at about 353°K is cooled to 303°K in a two cell cooling tower (13) and used for diluting the molasses in the distillery.

Due to the viscous nature of the spent-wash the final concentration is done in a single effect finishing pan operating under a pressure of 0.1598 bar. The finishing pan is fitted with a mechanical circulator to improve the heat transfer characteristics. Flash vapors of the hot condensates are used in the finishing pan for the final concentration. Vacuum is created by a barometric counter current condenser the non-condensable gases of which are removed by a water-jet ejector. The ejector water is recirculated to reduce the power load. The waste water from the condenser is cooled to 303°K in a cooling tower (13) and recycled. The concentrated spent wash at 80° Brix is discharged into a receiver fitted with heating elements (14) from where it is led into a jacketed screw conveyor (15) where filter mud or bagacillo is added to absorb the remaining moisture and to obtain a solid product for easy handling. The mixture may be elevated by means of a bucket elevator (16) for easy loading and bagging purposes.

MATERIAL AND HEAT BALANCE FOR A REVERSE FEED TRIPLE EFFECT EVAPORATOR WITH A THERMO-COMPRESSOR

Operating conditions —

1. Boiler pressure — 21.70 bar
2. Motive steam pressure to thermo-compressor — 20.596 bar
3. Temperature of motive steam — 573°K.
4. Steam pressure supplied to the first effect — 3.8245 bar
5. Vapor pressure of the last effect — 1.4709 bar
6. Specific heat of spent-wash at various stages.
   (i) Inlet to first effect — 0.90
   (ii) Inlet to second effect — 0.85
   (iii) Inlet to third effect — 0.80
   (iv) Inlet to finishing pan — 0.70
   (v) Outlet from finishing pan — 0.45
7. Total evaporation from 9°Bx to 80°Bx — 88.75 %
8. Pressure of the flash vapors to finishing pan — 1.2748 bar
9. Vapor pressure in the finishing pan — 0.1598 bar
10. Temperature of the spent-wash entering the last effect — 373°K.

Pressure distribution

The pressure distribution in the triple effect as given by Hugot is as follows:

\[
\frac{11}{30}, \quad \frac{10}{30}, \quad \frac{9}{30}
\]
Total pressure drop
\[= 3.8245 - 1.4709\]
\[= 2.3536 \text{ bar}\]

The pressure and temperature drops for the triple effect work out as follows:

<table>
<thead>
<tr>
<th>Steam</th>
<th>I Effect</th>
<th>II Effect</th>
<th>III Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (bar)</td>
<td>3.8245</td>
<td>2.1574</td>
<td>1.4709</td>
</tr>
<tr>
<td>Temperature (K)</td>
<td>415</td>
<td>395.65</td>
<td>383.79</td>
</tr>
</tbody>
</table>

Entertainment ratio for the thermo-compressor is calculated by Hugot\textsuperscript{6} and verified by Transvac\textsuperscript{6} by the formula

\[
(M_0 + 1)^2 = \frac{144}{(\log P - \log P_m) - 0.0056 (t_o - 212)}
\]

where \( M_0 \) = entertainment ratio

\( t_m \) = temperature of the mixture in °F corresponding to absolute pressure \( P_m \)

\( t_o \) = temperature in °F corresponding to absolute pressure \( P_o \) of the vapor from liquid

\( P \) = absolute pressure of the actuating steam in psi.

Substituting the values corresponding to above conditions we get,

\[ M_0 = 1.33 \text{ kg/kg of motive steam.} \]

The condition of steam after thermo-compression is found from the Mollier diagram which is at 3.8245 bar and 475.68°K. It is desuperheated to 415°K; by the first effect condensate; the quantity required being 0.1328 kg/kg of motive steam.

For ease of calculation the quantity of motive steam to thermo-compressor is assumed as 1 kg/hr. The material and heat balances for the triple effect and finishing pan are given below:

A. First Effect

<table>
<thead>
<tr>
<th>Input</th>
<th>Weight (Kg)</th>
<th>Heat (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td>2.4328</td>
<td>1590.078</td>
</tr>
<tr>
<td>Feed</td>
<td>2.2484 + 1.009235</td>
<td>220.613 + 99.026y</td>
</tr>
<tr>
<td>Total</td>
<td>4.6812 + 1.009235</td>
<td>1810.691 + 99.026y</td>
</tr>
</tbody>
</table>
### B. Second Effect

<table>
<thead>
<tr>
<th></th>
<th>Weight (Kg)</th>
<th>Heat (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vapor</td>
<td>0.9897 + 0.0009235y</td>
<td>644.1288 + 6.0101y</td>
</tr>
<tr>
<td>Feed</td>
<td>3.1589 + 1.01097y</td>
<td>298.0153 + 95.3764y</td>
</tr>
<tr>
<td>Total</td>
<td>4.1486 + 1.0202y</td>
<td>942.1441 + 101.3865y</td>
</tr>
<tr>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vapor</td>
<td>0.9105 + 0.0017433y</td>
<td>589.3666 + 1.1284y</td>
</tr>
<tr>
<td>Feed</td>
<td>2.2484 + 1.009235y</td>
<td>220.613 + 99.026y</td>
</tr>
<tr>
<td>Condensate</td>
<td>0.9897 + 0.0009235y</td>
<td>132.1249 + 1.2328y</td>
</tr>
<tr>
<td>Total</td>
<td>4.1486 + 1.0202y</td>
<td>942.1045 + 101.3872y</td>
</tr>
</tbody>
</table>

### C. Third Effect

<table>
<thead>
<tr>
<th></th>
<th>Weight (Kg)</th>
<th>Heat (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vapor</td>
<td>0.9755 + 0.001928y</td>
<td>631.4735 + 1.2479y</td>
</tr>
<tr>
<td>Feed</td>
<td>4.0568 + 1.00486y</td>
<td>385.292 + 90.4374y</td>
</tr>
<tr>
<td>Total</td>
<td>5.034 + 1.00679y</td>
<td>996.7665 + 91.6853y</td>
</tr>
<tr>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vapors</td>
<td>0.8999 - 0.0061079y</td>
<td>578.7256 - 3.9279y</td>
</tr>
<tr>
<td>Feed</td>
<td>3.1589 + 1.01097y</td>
<td>298.0153 + 95.3764y</td>
</tr>
<tr>
<td>Condensate</td>
<td>0.9755 + 0.001928y</td>
<td>119.9865 + 0.2371y</td>
</tr>
<tr>
<td>Total</td>
<td>5.0343 + 1.00679y</td>
<td>996.7274 + 91.6856y</td>
</tr>
</tbody>
</table>

### D. Finishing Pan

<table>
<thead>
<tr>
<th></th>
<th>Weight (Kg)</th>
<th>Heat (Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vapor</td>
<td>0.1266 + 0.0003342y</td>
<td>81.2139 + 0.2143y</td>
</tr>
<tr>
<td>Feed</td>
<td></td>
<td>93.016y</td>
</tr>
<tr>
<td>Total</td>
<td>0.1266 + 1.0003342y</td>
<td>81.2139 + 93.2303y</td>
</tr>
</tbody>
</table>
### Output

<table>
<thead>
<tr>
<th></th>
<th>Vapor</th>
<th>Feed</th>
<th>Condensate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1139 + 0.1114y</td>
<td>- 0.1139 + 0.8886y</td>
<td>0.1266 + 0.0003342y</td>
</tr>
<tr>
<td>Total</td>
<td>0.1266 + 1.0003342y</td>
<td>0.1266 + 0.8886y</td>
<td>81.19 + 93.2294y</td>
</tr>
</tbody>
</table>

From the material and heat balance we calculate:

(i) Input feed to 3rd effect = 0.8875(4.0588 + 1.00486y)

(ii) Output from finishing pan = - 0.1139 + 0.8886y

Total evaporation (i - ii) = 4.1727 + 0.11626y

Therefore 0.8875(4.0588 + 1.00486y) = 4.1727 + 0.11626y

\[ y = 0.7353 \text{ Kg/hr}. \]

Feed input to 3rd effect = 4.0588 + 1.00486y

= 4.798 Kg/hr.

Last effect vapors to distillery = 0.8999 - 0.0061079y

= 0.8954 Kg/hr.

Evaporation in the triple effect = 4.0588 + 0.00486y

= E \times (4.0588 + 1.00486y)

Therefore E = 84.67%

If the evaporation is 84.67%, the spent wash of 9.0 brix will get concentrated

\[ \frac{B - 9}{B} = 0.8467 \]

where \( B \) is the brix coming out of the first effect.

Total condensate obtained = 2.3 + (v_1 - 1.3) + v_2

= 1 + v_1 + v_2

= 4.1599 + 0.0109783y

Substituting the value of \( v \), we obtain

Total condensate = 4.1667 Kg/hr.

where

\[ v_1 = \text{Vapors from 1st effect} \]

\[ v_2 = \text{Vapors from 2nd effect} \]
For a distillery capacity of 30 KL per day and spent-wash quantity 540 KL per day the requirement of steam and production of vapor and condensate works out as follows:

1. Steam supplied to the first calandria of the evaporator  
   - 4.88 tons/hr.

2. Last effect vapors to distillery  
   - 4.37 tons/hr.

3. Adding 5% radiation loss, the actual steam requirement will be  
   - 5.12 tons/hr.

4. Out of the above 5.12 tons steam 4.37 tons vapor is taken to the distillery. Therefore the actual steam consumption for spent wash concentration will be  
   - 0.75 tons/hr.

5. Total condensate obtained  
   - 20.32 tons/hr.

6. Feed water required in the boiler for producing 5.12 tons per hour allowing for 3% blowdown and other losses  
   - 5.38 tons/hr.

7. The above requirement of feed water can be met out of the 20.32 tons of condensate obtained. The remaining quantity of condensate will be 14.94 tons per hour. This will be cooled to 303°K and used for molasses dilution. Allowing 2% loss due to evaporation and drift, this quantity will be reduced to  
   - 14.64 tons/hr.

Which will meet 75% of the requirement of dilution water.

RESULTS

1. For a distillery capacity of 30 KL per day the extra steam required for spent wash concentration is 0.75 tons per hour.

2. The evaporation rate of the existing distillery boilers improves by 8 to 9% with the use of hot condensate of 368°K for boiler feed purposes as compared to the use of raw water at 303°K which is the common practice in distilleries. The scaling in the boilers would be also reduced.
3. The heat from the condensate is used for heating the feed wash instead of the heat of the spent wash. Thus spent wash is obtained at a higher temperature which helps in reducing the steam consumption at the evaporator.

4. The cooled condensate is recycled for molasses dilution. This reduces the water requirement of the distillery for molasses dilution by 75%. This would help better yeast culture and hence better distillation efficiency.

5. The use of last effect vapors in the distillation column would help to recover any alcohol left in the spent wash.

6. The vapors of the last effect would be of a constant temperature, which is an important requirement for distillation.

7. The marginal additional requirement of steam for concentrating the spent wash can easily be met by the existing capacity of the distillery boilers, because of improved steam generation due to the use of the hot condensates as boiler feed.

ECONOMIC FEASIBILITY

I. Basis

1. Distillery capacity — 30 KL of alcohol/day
2. Spent-wash quantity — 540 KL per day
3. Total evaporation from 9°Bx to 80°Bx. — 88.75%
4. Steam supplied to the first effect of multiple effect evaporator — 5.12 tons per hour
5. Steam supplied to the distillery viz. vapor from the last effect of the evaporator — 4.37 tons per hour
6. Therefore net steam for spent-wash concentration (4 - 5) — 0.75 tons per hour

II. Quality and Quantity of the Resulting Product

The quantity of the concentrated spent-wash would be 62.50 tons and mixed with 10 tons of dry filter press mud giving a final product of about 72.50 tons. The composition on 100% solids is K<sub>2</sub>O: 10% N<sub>2</sub>: 1% and P<sub>2</sub>O<sub>5</sub>: 0.5%. The current price of K<sub>2</sub>O in India works to be Rs. 1200 ($144) per ton, that of nitrogen Rs. 3300 ($396) per ton and that of P<sub>2</sub>O<sub>5</sub> is Rs. 4000 ($480) per ton and press mud Rs. 10 ($1.2) per ton.

The daily quantities and values of the nutrients in the product, assuming specific gravity of spent-wash 1.03 and initial brix 9°, will be,
### Quantity per day

<table>
<thead>
<tr>
<th>Material</th>
<th>Value in Rs.</th>
<th>Value in US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>K₂O</td>
<td>6000</td>
<td>720</td>
</tr>
<tr>
<td>N₂</td>
<td>1650</td>
<td>198</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>1000</td>
<td>120</td>
</tr>
<tr>
<td>Press mud</td>
<td>100</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8750</strong></td>
<td><strong>1050</strong></td>
</tr>
</tbody>
</table>

Therefore the annual receipts (for 300 days) would be Rs. 26,25,000 ($3,15,000). The value per ton will be about Rs. 120.70 ($14.50).

### III. Requirement of Chemicals & Utilities:

1. **Cost of steam generation using furnace oil**
   - Cost for 300 days in Rs. U.S. $
     
     | Material | Consumption | Price per Kg. | Cost in Rs. | Cost in US $ |
     |----------|-------------|--------------|-------------|--------------|
     |          | 0.75 tons   | Rs. 1200     | 540,000     | 64,800       |

2. **Electricity**
   - 100 KW per hour at Rs. 0.25 ($0.03) per KWH.
   - Cost: 180,000 Rs. 21,600 US $

3. **Water**
   - 50 cu.m. per day at the rate Rs. 0.20 ($0.024) per cu.m.
   - Cost: 3,000 Rs. 360 US $

4. **Lime**
   - 2.7 tons per day at the rate of 5 gms per liter of spent wash at the price of Rs. 300 ($36) per ton of lime.
   - Cost: 243,000 Rs. 29,160 US $

5. **Press mud**
   - 10 tons per day at Rs. 10 ($1.2) per ton.
   - Cost: 30,000 Rs. 3,600 US $

**Total Chemical and utility cost per ton of final product Rs. 45.80 ($5.50)**

### Requirement of Manpower

<table>
<thead>
<tr>
<th>Role</th>
<th>Annual Cost in Rs.</th>
<th>U.S. $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chemical Engineer</td>
<td>24,000</td>
<td>2,880</td>
</tr>
<tr>
<td>2. Skilled staff</td>
<td>48,000</td>
<td>5,760</td>
</tr>
<tr>
<td>3. Operators</td>
<td>144,000</td>
<td>17,280</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>216,000</strong></td>
<td><strong>25,920</strong></td>
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A. R. PATIL AND J. T. JADHAV

Capital Investment

1. Plant & Machinery 1,250,000  150,000
2. Equipment staging and foundation 200,000  24,000
3. Land & Building 250,000  30,000
4. Miscellaneous 100,000  12,000

Total 1,800,000  216,000

The working capital requirement would be about Rs. 500,000 ($60,000).

VI. Balance Sheet

Expenditure in Rs. in Rs. U.S. $

1. Depreciation on Plant & Machinery @ 20% on Rs. 1,450,000 ($174,000) 290,000  34,800
2. Depreciation on Building @ 2.5% on Rs. 250,000 ($30,000) 6,250  750
3. Interest on Borrowed Capital about Rs. 1,500,000 ($180,000) at 12.5% interest 187,500  22,500
4. Interest on working capital of Rs. 500,000 ($60,000) at 15% interest 75,000  9,000
5. Overheads, repairs and maintenance 100,000  12,000
6. Labor costs 216,000  25,920
7. Steam cost 540,000  64,800
8. Electricity cost 180,000  21,600
9. Water 3,000  360
10. Lime 243,000  29,160
11. Press mud 30,000  3,600

Total 1,870,750  224,490
Total quantity of product = 21,750 ton
Therefore, per ton cost = $1,870,750 + 21,750 = Rs. 86.01 ($10.32)
Total return from the sale of the product = Rs. 2,625,000 ($315,000)
Sale proceeds per ton of the product = Rs. 120.70 ($14.50)
Therefore, return per ton = Rs. 34.69 (4.18)
Total return per annum = Rs. 754,507 ($90,915)

The investment would be recovered in about two and a half years.

VII. Other Monetary Gains

1. The distillery boiler evaporation rate is increased by 9% thus a fuel saving of 0.58 tons per day i.e., an indirect saving of Rs. 208,800 ($25,000) per year for the distillery, if cold water was used for boiler feed.

2. The dilution water requirement for distillery is decreased by about 14 tons per hour i.e., a saving of Rs. 20,160 ($2,400) per year.

This will reduce the production cost of alcohol.

DISCUSSION

The major item of cost viz. steam in the spent-wash concentration plant has been minimized and the cost of equipment has been reduced by the use of mild steel and ERW tubes.

It would not be very wrong to mention here that the scheme aims at the ultimate in steam economy for spent-wash concentration by the use of the latent heat of the last effect vapors for distillation of the feed wash in the distillery.

The sensible heat of the condensate is usefully employed for final concentration and heating of the feed wash.

Somewhat lower concentration in the multiple effect up to 55°60° brix has minimized problems of viscosity and boiling point elevation, thus achieving better heat utilization with a given heating surface.

Pressure evaporation and reverse feed have reduced viscosity problems at
higher concentration. The removal of spent-wash from the multiple effect at the highest temperature helps further concentration by flash evaporation from a temperature of $408^\circ K$ to $328^\circ K$ in the finishing pan.

The use of mechanical circulator in the finishing pan helps in achieving better heat transfer at high concentration. It should not be difficult to achieve concentration above $80^\circ$ brix also.

The total elimination of pollution hazard caused by distillery waste has been achieved by effecting thermal economy of steam in concentrating the spent-wash and minimizing plant cost.

REFERENCES


ECONOMIA DE VAPOR EN EL TRATAMIENTO DE LOS SOBRANTES DESECHABLES EN LAS DESTILERIAS, CONTADO CON LA CONCENTRACION DEL LAVADO-AGOTADO A TRAVES DE UN CICLO-CALORICO INTEGRAL

A. R. Patil y J. T. Jadhav

RESUMEN

Para eliminar el peligro de contaminacion causado por los lavados
agotados de fermentación en las destilerías, varios métodos han sido brevemente descritos. De estos el que más ha sido adaptado, consiste en la neutralización de los lavados-agotados, concentrados en un evaporador de múltiple efecto, seguido a concentrarse a 80 ° BRIX por un tacho, para después mezclarse con bagacillo o con cachaza presando y seca que proviene de las fabrías de azúcar, adoptándose como un fertilizante sólido rico en potasio.

En el sistema sugerido anteriormente se vuelve economicamente prohibitivo, ya que demanda consumo de vapor para la evaporación en el múltiple efecto, consumo de vapor en el tacho, en adición el vapor requerido para destilación.

En este trabajo técnico los autores sugieren un nuevo ciclo calórico, que reduce tan substancialmente el consumo total de vapor, que hace al sistema de mantenimientos de lavados-agotados desechables economicamente rentable.