SUMMARY OF FURFURAL CHEMICAL ECONOMICS

By

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1. Bagasse Versus Competing Raw Materials

(1) Oat hulls, cottonseed hulls and corn cobs are the important competing raw materials. All three have been used for commercial furfural manufacture. All three give a commercial yield of about one ton of refined furfural per 10 tons of raw material.

(2) Furfural sells at 9.5 cents a pound. At this price, furfural cannot be profitably manufactured unless the cost of oat hulls, cottonseed hulls or corn cobs is under $10 a ton. The cost of oat hulls and cottonseed hulls is governed by feed prices. Today, oat hulls and cottonseed hulls have a respective feed value of 34 and 25 dollars per ton. Corn cobs, on the other hand, are available at about $6 per ton, delivered. For this reason, corn cobs is the only raw material used for furfural manufacture today.

(3) Bagasse is worth about $2.50 per ton as fuel at the sugar plant, and gives a yield of about 8.5% of furfural as compared to the 10% yield obtained with corn cobs. This means that 100 lbs. of furfural requires the use of about $1.50 worth of bagasse by the sugar plant, against 3 dollars worth of corn cobs which is required by the Quaker Oats Co. to produce 100 lbs. of furfural at its plant.

(4) Data on Furfural Raw Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost $/per Ton</th>
<th>Furfural % Yield</th>
<th>% Furfural by Analyses</th>
<th>% Cellulose</th>
<th>% Lignin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bagasse</td>
<td>2.50</td>
<td>8.5</td>
<td>15</td>
<td>41</td>
<td>15</td>
</tr>
<tr>
<td>Corn Cobs</td>
<td>6.00</td>
<td>10</td>
<td>22</td>
<td>37</td>
<td>10</td>
</tr>
<tr>
<td>Oat Hulls</td>
<td>34.00</td>
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<td>22</td>
<td>34</td>
<td>13</td>
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<tr>
<td>Cottonseed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hulls</td>
<td>25.00</td>
<td>10</td>
<td>22</td>
<td>35</td>
<td>17</td>
</tr>
<tr>
<td>Rice Hulls</td>
<td>5.00</td>
<td>6</td>
<td>12</td>
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</tr>
</tbody>
</table>

2. Number of Furfural Manufacturers

(5) The Quaker Oats Co. is the only U.S. producer of furfural. It is being produced at the company's Cedar Rapids, Iowa plant and at the government Memphis, Tenn. plant. The latter is managed by Quaker and has a furfural capacity of 24 million pounds per year.

3. Production and Use-Distribution

(6) Prewar furfural production was about 11 million pounds per year and the
use of furfural by the petroleum industry as a selective solvent in lubricating oil manufacture accounted at that time for about 60% of furfural production.

(7) The commercial use of furfural as an extractive distillation solvent in the manufacture of butadiene was begun in 1943 and caused a four time increase in furfural demand. This resulted in an increase of furfural consumption to 55 million pounds per year and in the erection of the Memphis, Tenn. furfural plant. Today, furfural production and sales are continuing at the rate of about 55 million pounds a year.

(8) The other important furfural uses are the production of furan resins which accounts for about 15% of total furfural consumption, and the selective solvent extraction of wood rosin and linseed oil.

(9) The planned use by the Du Pont Co. of furfural for the production of nylon raw material, i.e. adiponitrile, will mean further furfural production expansion. It is presumed that when Du Pont completes its Niagara Falls adiponitrile plant, that this will involve an additional 20 million pound furfural consumption.

4. The Furfural Manufacturing Process

(10) Corn cobs are placed in spherical shaped pressure cookers lined internally with carbon bricks bonded together with acid-resistant cement. The cobs are moistened with a 5% sulphuric acid solution by adding about one pound of 5% acid solution per 3 pounds of corn cobs. The process cooker, i.e. the digester is then closed and live steam added until an internal pressure of 70 psi is developed. The digester is kept at this pressure for 8 hours and during this entire period a continuous stream of steam containing about 10% by weight of furfural is removed from the digester while simultaneously a fresh supply of steam is added to the digester to maintain the pressure at 70 psi.

The steam-furfural mixture leaving the digester also contains volatile impurities, particularly methanol and acetic acid. This mixture is passed, while still under pressure, into a large drum where the pressure is reduced and occluded fibrous impurities are separated. The furfural-steam mixture is then passed through a continuous copper bubbling-plate type fractionating column whereby a two-phase liquid condensate consisting of a water layer and a furfural layer are obtained.

The water layer comprises about 16% of the total condensate and consists of water containing methanol and some acetic acid. This alcoholic water is fractionally distilled and the methanol is recovered.

The other liquid layer consists of crude furfural. The latter is refined to a 99% purity furfural by subjecting it to a specially designed continuous dryer wherein the moisture and other volatile impurities are removed by heating the crude furfural by means of a 100 psi steam coil to just below the boiling point of furfural, i.e. about 320° F.

It takes about 20 lbs. of steam to produce one lb. of furfural.
The black residue remaining in the digester is flash dried and is either used as fuel by the furfural plants boilers or is sold for use as a fertilizer binder wherein it has a value of about 8 dollars a ton.

5. The Reasons For High Furfural Plant Investment Costs

(11) In the laboratory, furfural is a comparatively simple chemical to make. A furfural manufacturing plant, however, involves difficult and costly chemical engineering problems. The strong acid converting solutions as well as the acidic nature of the crude furfural liquors introduce serious corrosion problems which have necessitated expensive corrosion resistant equipment throughout a furfural plant. Another high cost factor is the large steam consumption with its accompanying high boiler house capacity requirement.

Because of the high plant investment cost, low cost furfural cannot be made without large volume furfural production. The Quaker Oats Co. has followed the policy of maintaining a low furfural price. From Quaker's standpoint, this is sound policy, since low furfural price coupled with high plant investment cost has thus far discouraged others from entering the furfural field.

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