THE LOTUS ROLL

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ABSTRACT

The mixture of juice and fiber in the cane blanket passing at the pitch of the mill rolls under high pressure exists in a “semi-liquid” state, a factor considered harmful to both mill extraction and capacity. The semi-liquid zone is harmful to extraction because the portion of the extruded semi-liquid is reabsorbed by the bagasse and is harmful to capacity because the roll surfaces have no grip on this semi-fluid material.

Used as the top roll of the milling tandem, the Lotus Roll is designed to specifically eliminate this “semi-liquid” state. It is designed with its cast steel shell containing axial rows of perforations, each row being connected to a collecting channel built into the shell. The extracted juice, normally trapped at the upper region of the cane blanket, is forced through the surface perforations and discharged at both ends of the collection channels.

The Lotus Roll perforations allow a ready egress path for the semi-liquid at the region where it is generated, and extend the gripping zone into the maximum pressure region, thereby increasing the gripping force at the rolls on the bagasse blanket.

Performance of the Lotus Roll installed at Jente Sugar Factory in Taiwan is described.

INTRODUCTION

The conventional mill roll, with its cast shell, has served the Industry well but, like any other piece of equipment, it has its limitations.

The purpose of the Lotus Roll is to extend these limits to boundaries which will enable the miller to process more cane at higher level of performance, with its existing milling tandem.
Description

The Lotus Roll has a cast steel shell which has conventional (or near-conventional) circumferential grooving. The surface of the shell is perforated arranged in axial rows. Each row of perforations is connected to a collecting channel built into the shell. Both ends of each connecting channel are opened to the atmosphere.

Extracted juice, which is normally trapped at the upper region of the cane blanket, is forced through the surface perforations and is discharged at both ends of the collecting channels.

The extracted juice emerges from the Lotus Roll at points which do not cause contamination of the mill roll bearings by the juice, since these discharge points are between the lower rolls and below the top roll bearing.

Operating Principle

Hugot reports that, as far back as 1928, Egeter in Java discovered that . . . . . .

"The volume of the compressed bagasse, as it passes between the rollers, is greater than the volume generated by the roller."

This phenomenon has been confirmed by the work of Murry and Bullock in Australia, and has been described as being an "Extrusion" process, happening because the mixture of juice and fiber under high pressure at the pitch of the rolls is in a "Semi-liquid" state.

The Lotus Roll has been specifically designed to eliminate this semi-liquid zone because it is the inventor’s contention that the presence of this semi-liquid is harmful to both extraction and capacity.

It is harmful to extraction because the portion of the semi-liquid which is "extruded" is reabsorbed by the bagasse. Part of the work performed by the mill is therefore wasted and the juice which is carried over to the next mill helps to create another semi-liquid zone.

The semi-liquid zone is harmful to capacity because the roll surfaces have no grip on a semi-fluid material. The larger the volume of the semi-liquid material, the smaller becomes the effective gripping area of the rolls.

This concept is illustrated in Fig. 1. When the semi-liquid zone extends from 0 to B, the gripping zone extends from B to A. If the semi-liquid zone is extended to B, the gripping zone is reduced by an amount equivalent to BB’.

As the volume of semi-liquid increases (due to increased grinding rate and/or increased imbibition and/or reduced juice drainage), the gripping area decreases and
eventually the mill slips. The mill operators are well aware of the ill-effects of excess fluid at the nip of the rolls because they instinctively reduce the maceration when the rolls start to slip.

The semi-liquid zone exists because the liquid generated by the crushing action of the rolls does not have an adequate escape path. It therefore has to flow backwards, i.e. against the direction of flow of the bagasse, until it reaches a sufficiently loose zone of bagasse allowing it to percolate down to the surface of the bottom roll, and from there, to the juice tray.

The perforations of the lotus roll allow a ready egress path for the semi-liquid, at the very region where it is generated.

Furthermore, the lotus perforations extend the gripping zone into the region of maximum pressure and therefore increase the gripping force of the rolls on the bagasse blanket to values which have never been experienced previously.

This theory seems to have been confirmed by the performance of the prototype Lotus Roll at Jente. For all intents and purposes, the Jente roll was a "Flat" roll with very few teeth. The large flat surfaces of the roll soon became very polished. Anyone looking at the roll would have to say that such a roll cannot possibly work. In fact, the Jente Roll allowed the mill to reach capacity peaks which were unheard of in the history of Jente.

**FIGURE 1.** Shows how the semi-liquid zone is harmful to both extraction and capacity.
The Jente roll had only half the number of teeth of its conventional counterpart, because of a misconception that we had. The Jente experience taught us how to have the full complement of teeth while maintaining the same number of perforations. The rolls now owing manufactured will have all the teeth in, and will therefore be identical to the conventional roll as far as circumferential grooving is concerned.

RESULTS AND DISCUSSION

Effect of the Lotus Roll of the capacity of individual mill units

The expected capacity increase is not readily calculable. Based on the Jente experience, we can only guess that a Lotus Roll, with its full complement of grooves and adequately hardfaced by arc-welding by the operator, during operation, will allow a capacity increase of at least 50% over the capacity of the mill with a conventional top roll.

Effect of the Lotus Roll on the extraction of individual mill units

Bearing in mind that our experience is very limited, we contend that a lotus top roll will increase the extraction of any particular 3-roll mill by about 10%.

Effect of the Lotus Roll on the extraction of tandems

The effect of the Lotus Roll on the extraction of tandems is calculable, as long as certain assumptions are made. Such calculations is intended to serve only as a guide showing the order of magnitude of the improvement expected.

Let it be assumed that:

a) Every top roll of the tandem is of the Lotus type

b) In a conventional tandem, the first mill unit extracts 60% and each subsequent mill unit extracts 40% of the sucrose entering the mill.

c) In a tandem with a Lotus top roll at each mill, the extraction at the 1st mill is 66% and at every subsequent mill 44%.

Table 1 shows a calculation based on these assumptions and predicts a gain of 1.84 points for a tandem of 5-mill units.

Table 2 shows that while a 5 mill tandem would derive substantial extraction benefits from the Lotus Rolls, the benefits derived from a shorter tandem would be even more pronounced.
TABLE 1. Sucrose-balance comparison between a conventional tandem of 5 mills and an equivalent tandem having Lotus rolls as top rolls

<table>
<thead>
<tr>
<th></th>
<th>Conventional Tandem</th>
<th>Lotus Roll Tandem</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Suc. extracted by 1st mill</td>
<td>60</td>
<td>66</td>
</tr>
<tr>
<td>% Suc. extracted by 2nd mill</td>
<td>40</td>
<td>34</td>
</tr>
<tr>
<td>% Suc. extracted by 3rd mill</td>
<td>24</td>
<td>19.04</td>
</tr>
<tr>
<td>% Suc. extracted by 4th mill</td>
<td>14.4</td>
<td>10.66</td>
</tr>
<tr>
<td>% Suc. extracted by 5th mill</td>
<td>8.65</td>
<td>5.97</td>
</tr>
<tr>
<td>% Suc. left in the bagasse</td>
<td>5.18</td>
<td>3.34</td>
</tr>
<tr>
<td>% extraction = 100 – sucrose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lost in bagasse (% of original sucrose)</td>
<td>94.82</td>
<td>96.66</td>
</tr>
</tbody>
</table>

Effect of the number of mills in a tandem on the benefits derived from the Lotus Roll

The data presented in Table 2 have been put in graph form (Fig. 2) thus showing that a 4-mill tandem with Lotus Rolls as top rolls would have the same extraction as a conventional tandem of 5 mills. Equally, a 3-mill Lotus tandem is almost equal in extraction to a 4-mill conventional tandem.

TABLE 2. Effect of the number of mills in a tandem over the benefits derived from the Lotus Rolls

<table>
<thead>
<tr>
<th>Number of mills in the tandem</th>
<th>Extraction %</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Conventional Tandem</td>
</tr>
<tr>
<td>2</td>
<td>76.00</td>
</tr>
<tr>
<td>3</td>
<td>85.80</td>
</tr>
<tr>
<td>4</td>
<td>91.36</td>
</tr>
<tr>
<td>5</td>
<td>94.82</td>
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</table>
ADVANTAGES OF THE LOTUS ROLL

The advantages of the Lotus Roll, over conventional rolls, can be summarized as follows:

1. **Reliability.** The shell, being of cast steel, should not crack as the cast iron shells tend to do. Also, due to the immense support provided by the cast steel shell, shaft-breakage under the shell should be eliminated.

2. **Life expectancy.** We expect a long life from the Lotus Roll for the following reasons: Teeth-breakage should not occur with a cast steel shell, as it does with a cast iron shell. If it occurs, the teeth would be easily repaired while a broken cast iron tooth cannot be satisfactorily repaired.

The Lotus Roll, of cast steel, can be arc-welded during operation by any number of hardfacing and/or corrosion-resisting electrodes. The roll diameter could easily be maintained during the whole crop.

3. **Aggressiveness.** If a corrosion-resisting type of electrode were used to arc the roll, the exposed base metal of the shell would corrode faster than the deposited metal. This differential corrosion rate would have for effect to increase the roughness of the roll surface with age, rather than decrease it.

4. **Capacity.** We expect a capacity increase of at least 50%.

5. **Extraction.** We expect a 2% to 4% increase in extraction of tandems having an average performance.
It is interesting to note that, since the Lotus roll provides a very high juice-drainage capacity, this feature could be made use of in an unconventional way, helping towards obtaining a higher extraction. The maceration juice from a particular mill could be circulated (in part) to the same mill.

By this method, no additional load would be imposed on the evaporators, although the additional (recirculated) fluid poured over the bagasse would extract more molasses through the process of lixiviation.

6. **Bagasse moisture.** Should be improved by the Lotus Roll. The Lotus roll, on order for Puunene in Hawaii should prove this point since it will be used as the top roll of the last mill.

Any reduction of the bagasse moisture would not only increase the extraction but also reduce the fossil-fuel bill (if any) of the company.

**HISTORICAL BACKGROUND OF THE LOTUS ROLL**

The first perforated roll was tried at the factory of Nanchow, Taiwan. The perforations plugged-up within minutes.

The second prototype operated very successfully at the factory of Jente, also in Taiwan. During the crop, in February 1978, the top roll of the first mill was removed and replaced by the Lotus Roll.

The Lotus Roll operated very well for the rest of the season which ended on April 22, except for a period of 10 days during which the Lotus roll was removed to try a different configuration of perforations on part of the roll.

Mr. K.T. Wang, the manager of Jente and one of the most successful managers of the Taiwan Sugar Corporation, took a very special interest in the trials of the Lotus Roll. We wanted to install the Lotus on the last mill but Mr. Wang preferred it on the first mill because Jente had been suffering from the inability of the first mill to feed properly, due to a tremendous juice-flooding problem. The Lotus Roll eliminated the flooding problem completely and the grinding rate was increased.

It is unfortunate that Jente added an underfeed roll to each mill as well as trying the Lotus roll. These two simultaneous changes made it difficult to assess the effects of the Lotus Roll on the mill performance. However, the results are as follows:

1. The Lotus Roll eliminated the juice flooding at the 1st mill.

2. The official results show a peak capacity of 105 TCH with the conven-
tional roll and 120 TCH with the Lotus Roll.

3. The bagasse pol, which was traditionally at about 2.8%, dropped to 2.3% with the Lotus Roll in operation. (This figure is not on the official report but can be easily confirmed.)

4. The actual juice extraction at the 1st mill was slightly improved by the Lotus Roll, as shown below:

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Peak</th>
</tr>
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<tbody>
<tr>
<td>Juice extraction with the conventional roll</td>
<td>50.77%</td>
<td>53.18%</td>
</tr>
<tr>
<td>Juice extraction with the Lotus roll as top roll</td>
<td>51.77%</td>
<td>59.88%</td>
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</table>

5. The juice extraction of the 2nd mill increased appreciably with the Lotus Roll in first position.

The factory of Puunene in Hawaii has ordered a Lotus Roll as top roll for the last mill of one of its 2 tandems. It will be tried within the next 4 months. The roll will be 40" x 78" with 3/4" grooving at 45°. There will be no cross grooves. Jente (where the prototype was tried this year) has ordered 3 more rolls of the Lotus type for the other mills of its tandem.

**LA MAZA LOTUS, UN NUEVO CONCEPTO DE MOLIENDA**

Jean Bouvet

**RESUMEN**

La mezcla de jugo y fibra en el colchon de caña, pasando a través del paso de las mazas de los molinos bajo alta presión, existe en un estado semi-liquido, lo cual es un factor considerado dañino tanto para la extracción como para la capacidad. La zona semiliquida es dañina para la extracción porque el sector de la extracción semi-liquida es reabsorbida por el bagazo, y es dañina también para la capacidad, porque la superficie de las mazas no tiene agarre en este material semi-liquido.

Usada como maza superior en un tandem de molinos, la maza Lotus está diseñada específicamente para eliminar ese estado semiliquido. La enaqueta o concha esta diseñada de acero fundido, conteniendo hileras de perforaciones exiales, cada hilera está conectada a un canal colector construido dentro de las chaquetas. El jugo extraído.
normalmente flotando atrapado en la parte superior del colchón de caña es forzado a pasar a través de la superficie perforaciones y descargado en ambos lados de los canales colectores.

Las perforaciones de la maza Lotus permiten un paso fluido en la región en donde se genera el estado semi-liquido y aumenta el agarre en la región de máxima presión, de esta manera aumentando la fuerza de agarre de las mazas sobre el colchón de bagazo.

Se describe el comportamiento de la maza Lotus instalada en el Ingenio Jente en Taiwan.