INDUSTRIAL EVALUATION OF PRE-LIMING IN THE TANDEM TO REDUCE WEAR OF THE SUGAR MACHINERY

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Abstract

Pre-liming in sugar mill tandems is evaluated as a measure to reduce wear in this area. It was concluded that pre-liming does not affect the fundamental technological parameters of sugar manufacture. Systems are proposed for the implementation of pre-liming based on the peculiarities of each mill, but always adding one-third of the total purification lime on the juice stream from the last mill.

Key words: Wear, tandem, milk of lime.

Introduction

The importance of wear of the tandem machinery has been pointed out by Mondul et al., Uller et al., etc. and its close connection to corrosion has been shown. The combined mechanical corrosion effect play an important role in this wear and the total resulting effect has been proven by Mondul et al. to be greater than the sum of individual effects.

Considering this, the addition of milk of lime in the tandem had been recommended by Mondul et al. as a way to increase the pH value of sugar fluids and thus reduce the wear provoked. The effect of the reduction of the acidity of juice on some equipment of the area being quantified in simulated conditions. However, the recommendation had not been materialized in detail or its effects evaluated in the technological process in operation conditions of a sugar mill.

The results of the evaluation of this wear reduction system in the area of juice extraction of a Cuban sugar mill are reported in this paper.
FACTORY ENGINEERING

MATERIALS AND METHODS

The juice of a Cuban sugar factory milling 1,100 t of cane a day was pre-limed by putting lime on the channel of the fifth mill with a flow speed around 15 l/min for two 10-day periods (January 16-26 and February 13-25) of the 1989-90 cane season. The technological behaviour of the season was monitored through the parameters customarily measured at the mill lab. This plant has a tandem of five straight mills with compound maceration and 21-22% imbibition on cane.

Additional, measurements of pH, Ca²⁺, reducing sugars in juice, etc. were made according to traditional methods of the sugar industry.

Corrosion rate was obtained through the classic gravimetric technique using 50 x 20 mm coupons suspended in the juice. The system for adding the milk of lime can be varied depending on the location of the liming area within the plant in relation to the milk. By virtue of this the addition can be more or less complex.

For this evaluation, the system was built in a way similar to a lime dosifier. The lime dosifier allowed, through a unique opening, a lime flow of around 15 l/min, roughly one third of the total used for juice liming in the plant. The system was automated in such a way that lime was only added while the fifth mill motor was running. It would have been equally valid to use operation of the motor of the pump supplying mixed juice to the liming tank as the control signal. This system is able to automatically stop pre-liming every time the tandem stops. Significant disadvantage of the selected system from the viewpoint of its evaluation was the impossibility of maintaining a constant flow. The flow was determined by a number of factors such as the lime flow arriving in the dosifier, the scaling rate of this equipment, etc. Correspondingly, variations in milk concentration, and lime quality imply difficult-to-control variations of pre-liming. These factors, relatively important for the evaluation work, are of little significance to the real usefulness of pre-liming.

The juice pH values for the five mills suffered some differences as seen in Figure 1, which shows average values for the test period.
Other addition systems can be used. These range from a direct pipeline from the lime tank with manual control of the appropriate flow to more complex systems with pH or corrosion rate control by means of corrosimeters. In the latter case not only juice acidity, but also other factors affecting the corrosion rate of metallic structures would be taken into account.

Each system mentioned implies different resources and technologies, though relatively well-known in sugar mills. On the other hand, the system of pipelines, valves and the rest of piping fitting requires the special attention devoted to milk of lime handling. Location and other details are conditioned by the specific characteristics of each sugar mill.

![Graph showing pH values of juice while pre-liming by putting milk of lime on the channel of the fifth mill.](image)

**FIGURE 1.** Average pH value of juice while pre-liming by putting milk of lime on the channel of the fifth mill.
Industrial evaluation of pre-liming

During the evaluation period no significant variation that might have been attributed to pre-liming was observed in the most important manufacturing parameters (recovery, ash in and purity of final molasses, pol in bagasse and resazurine test among others). This is in accordance with classic sugar literature, which recommends, in cases in which ordinary liming is insufficient, a previous alkalinization, precisely with one third of the lime, followed by heating and subsequent final liming, according to Hugot.1

The resazurine test indicated that pre-liming was not harmful from the microbiological point of view. This criterion was supported by determinations of reducing sugars with and without pre-liming (which did not show remarkable differences) and microbiological countings in juice samples. Quite the contrary, the relatively high pH values reached in the last mills might have some disinfecting effect.

The determination of some characteristics of bagasse (Table 1), shows that among the parameters measured only the Ca²⁺ and pH content of extracted juice differ remarkably. The increase of the former could be associated with an increase in lime consumption.

**Table 1. Parameters determined in bagasse.**

<table>
<thead>
<tr>
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<th>Without pre-liming</th>
<th>Pre-limed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Standard No. of Deviation Samples</td>
<td>Average Standard No. of Deviation Samples</td>
</tr>
<tr>
<td>pH*</td>
<td>5.10 ± 0.18 4</td>
<td>7.01 ± 0.63 22</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>44.69 ± 1.34 6</td>
<td>46.70 ± 3.09 11</td>
</tr>
<tr>
<td>Ash (% bs)</td>
<td>3.37 ± 1.81 4</td>
<td>4.25 ± 2.01 6</td>
</tr>
<tr>
<td>Ca²⁺ (ppm)</td>
<td>150 ± 49 5</td>
<td>588 ± 210 10</td>
</tr>
</tbody>
</table>

The increase in calcium content does not augment the ash content in bagasse for its does not represent a noticeable amount as compared to its regular ash content. It was also found that pre-liming in the tandem did not cause additional troubles in the bagasse boilers.

The consumption of CaO per ton of cane milled along the season, including the 10-day periods of pre-liming is shown in Figure 2.
There is no evidence of an increase in lime consumption during the pre-liming period. This apparent contradiction with the increase of Ca\(^{2+}\) in bagasse (Table 1) can be explained in the following terms:

![Graph showing lime consumption variation in g CaO/1000 t of cane in the sugar mill where pre-liming was practiced along the cane season.](image)

**Figure 2.** Lime consumption variation in g CaO/1000 t of cane in the sugar mill where pre-liming was practiced along the cane season.
Variations in lime consumption from a 10-day period to another are too sharp and mask variations caused by pre-liming.

The calcium detected in bagasse cannot be considered totally lost because when a partial precipitation occurs in the tandem the mat can work as a filter in which part of the follicles are retained (thus affecting not only a preliming but a pre-purification too).

Sand particles and other lime-constituent solids are retained in the bagasse mat which are not part of the CaO serviceable to the juice and they are determined as Ca$^{2+}$ in the juice extracted from bagasse through pressing.

Nevertheless, even if pre-liming did imply an increase in lime consumption the fact should be considered that this lime would not be entering the process and thus would bring about no further consequences in the plant, being only relevant to later uses of bagasse. On the other hand, the increases in Ca$^{2+}$ content in juice going to the heaters caused no special problem in this equipment during the test periods.

Table 2 shows corrosion rate values gravimetrically determined for a common steel in pre-limed and not pre-limed juice (complete immersion and without relative metal-juice movement). Due to the addition method used, the greatest effect on corrosion rate is achieved in the last mills, an area in which wear is greater due to the greater influence of mechanical factors and in which the retardation effect on wear is all the more necessary.

**TABLE 2.** Corrosion rates (g/m$^2$h) gravimetrically determined for common steel in juice of the different mills with and without pre-liming.

<table>
<thead>
<tr>
<th>Mill</th>
<th>Without Pre-liming</th>
<th>Pre-limed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crusher</td>
<td>1.19</td>
<td>0.62</td>
</tr>
<tr>
<td>1st Mill</td>
<td>1.27</td>
<td>0.32</td>
</tr>
<tr>
<td>2nd Mill</td>
<td>1.13</td>
<td>0.36</td>
</tr>
<tr>
<td>3rd Mill</td>
<td>0.77</td>
<td>0.04</td>
</tr>
<tr>
<td>4th Mill</td>
<td>0.50</td>
<td>0.01</td>
</tr>
<tr>
<td>5th Mill</td>
<td>0.12</td>
<td>0.00</td>
</tr>
<tr>
<td>Mixed Juice</td>
<td>1.20</td>
<td>0.56</td>
</tr>
</tbody>
</table>

These results only represent an instance of the protective effect of pre-liming on wear. The different operating conditions of different equipment imply different action mechanisms of pH increase. Even though there are some
estimates in this respect, detailed study is needed on the effect of pre-liming on the wear and life of all such equipment in contact with juice over a long period. Such results would be indispensable for an exact appraisal of the economic effect of this technology.

CONCLUSIONS

The proposed system for juice pre-liming in the tandem was found to reduce the wear of metallic structures in contact with juice without significantly affecting the technological parameters of sugar manufacture. There are a number of ways of applying pre-liming depending on the characteristics of each mill. In all cases, the addition of one third of the total milk of lime on the juice stream from the last mill is recommended. Final bagasse was found to have the same general characteristics when the juice was pre-limed and when it was not. Exceptions were the pH value of the juice in the bagasse (which augments by nearly 2 units) and the calcium content (roughly four times its regular value on the average).

REFERENCES

EVALUATION SUR LE PLAN INDUSTRIEL DU PRECHAUlage AUX MOULINS POUR REDUIRE L'USURE DE L'EQUIPEMENT

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RESUME

Le prechaulage aux moulins a été évalué pour réduire l'usure de l'équipement. Ce prechaulage n'affecte pas la marche de la sucrerie. Des systèmes sont proposés pour l'adoption du prechaulage, base sur les particularités de chaque train de moulins, mais il faut toujours ajouter un tiers de la quantité totale de la chaux au dernier moulin.

EVALUACION INDUSTRIAL DEL PREALCALIZADO EN EL TANDEM PARA DISMINUIR EL DESGASTE DE LA MAQUINARIA AZUCARERA

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RESUMEN

Se evalúa industrialmente el prealcalizado en el tandem de los centrales azucareros como medida para disminuir el desgaste en esta área y se llega a la conclusión de que no afecta los parámetros tecnológicos fundamentales de la producción de azúcar. Se proponen algunos sistemas para la implementación de este prealcalizado en dependencia de las particularidades de cada central, pero siempre con la adición de un tercio de cal total para la purificación en la canal del último molino.

Palabras claves: Desgaste, tandem, lechada de cal.