Development of a two-roller cane mill and its performance at Indian Cane Power Ltd, Karnataka, India

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Abstract  Indian Cane Power Ltd (ICPL) was established in 2005 as a cogeneration sugar plant for export of green power to the grid. Initial plant capacity was 5000 t cane/d. Original milling tandem, comprising four 107 cm x 214 cm size conventional three-roller mills with an under-feed roller (UFR), has been steadily expanded to 12,500 t cane/d in three phases from 2011 to 2014. thyssenkrupp proposed to install a newly developed design of two-roller mills, in the available limited space, to achieve the targeted capacity of 12,500 t cane/d. The first two-roller mill of 127 cm x 254 cm size was commissioned in 2011 season as the last mill. It was provided with grooved roller pressure feeders (GRPF). After proving the good performance of the new design, ICPL repeated the order for the same size mill as the zero mill. The new two-roller mill design has proven to be reliable while handling high capacity and has given satisfactory performance. The milling plant has crushed approximately 1,300,000 t of cane in the 2015-16 season and ICPL have two cogeneration power plants of 28 MW and 55 MW. This paper documents the performance and operational experience of the newly developed design of a two-roller mill at the ICPL sugar plant.

Key words  Cane preparation, mill types, two-roller mill, Indian sugar industry

INTRODUCTION

The Indian cane sugar industry has undergone a major change in last decade with a new government policy that allows sugar plants to export excess power to the grid. Tables 1 and Table 2 briefly summarise the evolution of cane preparation systems and cane mill configurations in the Indian Sugar Industry. Most sugar plants are currently achieving 85-90 Preparatory Index (PI) and plant capacities have increased steadily.

However, sugar plants are investing in energy efficient equipment to reduce the power consumption in the plant processes, so that more power is available for export. The typical white-sugar plant in India, with electrical drives, consumes about 50-60% of total power for the cane preparation and milling plant. Hence, ICPL was seeking an energy efficient solution with better results than conventional mills.

This paper documents the performance and operational experience of the newly developed design of a two-roller mill at the ICPL sugar plant.

DISADVANTAGES OF THREE-ROLLER MILLS

The top roller transmits power to the feed and discharge roller and also transfers hydraulic load - thus it needs a larger shaft and bearings. Due to standardisation of rollers, mills are oversized. Cane preparation work done while dragging the bagasse over the trash plate is now not required, as cane is already well prepared with 90 PI. The trash plate obstructs free juice drainage and leads to higher re-absorption losses, due to spongy nature of well-prepared bagasse (Fig. 1). In three-roller mills, the trash plate absorbs approximately 25% of the hydraulic load applied to the top roller. Only about 75% of the hydraulic load is utilized for useful compression (Hugot 1986).

TK TWO-ROLLER MILL

The concept of two-roller mill was introduced in 2000 (Chohan and Garson 2009, Trancart 2008). thyssenkrupp adopted an approach where the mill rollers are arranged inclined at 10° with the vertical and have hydraulic load directly applied on the top floating roller (Fig. 2). This arrangement helps to separate solid bagasse moving out horizontally, from the juice
which drains down vertically. The new design (Figs 3-5) incorporates a unique floating re-absorption limiting (RAL) device, which prevents the bagasse from freely expanding after compression. This minimizes the re-absorption of juice and conveys the bagasse away from the juice extraction zone. The hydraulic force on mill rollers is the primary force for extraction. A small hydraulic cylinder is also applied to RAL unit and its pressure can be adjusted to optimise frictional loss in the RAL unit. Operating parameters are given in Table 3.

**Table 1. Typical cane preparation system evolution in India.**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Arrangement</th>
<th>Capacity, PI, kW/tfh, Timeline</th>
</tr>
</thead>
</table>
| Kicker+ 1st Knife+ 2nd Knife | ![Diagram](image1) | Capacity = 1250 tcd
Pl = 60
kW/tfh = 38 to 45
Year: 1960 to 1980 |
| Kicker+ 1st Knife+ Heavy Duty Reverse Cutter | ![Diagram](image2) | Capacity = 2500 tcd
Pl = 70 to 75
kW/tfh = 40 to 50
Year: 1980 to 1990 |
| Kicker+ Knife+ Fixed Hammer Fiberizor 90° Anvil | ![Diagram](image3) | Capacity = 5000 tcd
Pl = 80 to 85
kW/tfh = 45 to 55
Year: 1985 to 1995 |
| Kicker+ Knife+ Pusher drum, Swing Hammer Fiberizor/Shredder 160° Anvil | ![Diagram](image4) | Capacity = 7500 tcd
Pl = 85 to 90
kW/tfh = 60 to 68
Year: 1995 onwards |
| Chopper / Cane stabilizer & density enhancer (CSDE)+ Pusher drum+ Fiberizer 135° Anvil+ Shredder | ![Diagram](image5) | Capacity ≥ 10,000 tcd
Pl ≥ 90, Mill & Diffuser
kW/tfh = 75 to 83
Year: 2000 onwards |
**Table 2.** Developments of mill configurations in India.

<table>
<thead>
<tr>
<th>Description</th>
<th>Mill configuration</th>
<th>Development year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-Roller Mill</td>
<td>Gravity+ Pressure Feed</td>
<td>1900-1970</td>
</tr>
<tr>
<td>Four-Roller Mill</td>
<td>Gravity+ Pressure Feed</td>
<td>1970-1980</td>
</tr>
<tr>
<td>Five-Roller Mill</td>
<td>Gravity+ Pressure Feed</td>
<td>1980-2005</td>
</tr>
<tr>
<td>Six-Roller Mill</td>
<td>Gravity+ Pressure Feed</td>
<td>1980-2005</td>
</tr>
<tr>
<td>Two-Roller Mill (Two Roller+ Under Feeder)</td>
<td>Gravity Feed+ Juice Re-absorption Limiting Unit. Top Roller Fixed</td>
<td>2000-2010</td>
</tr>
<tr>
<td>Two-Roller Mill (Two-Roller+ Pr. Feeder)</td>
<td>Gravity+ Pressure Feed+ Juice Re-absorption Limiting Unit (Floating &amp; Adjustable)+ Top roller floating with direct acting hydraulics.</td>
<td>2010-2015</td>
</tr>
</tbody>
</table>
Fig. 1. Hydraulic load distribution in conventional three-roller mill.

Fig. 2. Hydraulic load distribution and assembly of two roller mill with easy juice drainage.

Fig. 3. Final configuration of 12,500 t cane/d milling plant.
The mill ensures free juice drainage by use of lotus nozzles on top and bottom roller and messchaert grooves at every alternate groove in the bottom roller. Both rollers are made of double-sleeve construction with herringbone lotus holes cast in the inner sleeve giving excellent drainage. Only the outer sleeve is replaced during re-shelling, thus reducing maintenance costs. The diameter of rolls can be easily adjusted to incorporate additional wear allowance. A small speed differential is introduced between top and bottom roller, which helps in better extraction.

The mill is flexible and can be fed with a toothed under-feed roller or with either toothed or grooved pressure feeders.

Results before and after installation of the fifth mill and after the installation of the zero mill are given in Tables 4-6.
Table 4. Results before the installation of the fifth mill (2010-11 season).

<table>
<thead>
<tr>
<th>Cane crushed (t/d)</th>
<th>Fibre % cane</th>
<th>PI</th>
<th>First three-roller mill +GRPF (42”x84”)</th>
<th>Fourth three-roller mill +GRPF (42”x84”)</th>
<th>Reduced Mill Extraction (RME)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>kW/t/h</td>
<td>Average primary extraction (pol basis)</td>
<td>kW/t/h</td>
</tr>
<tr>
<td>6,500-7,000</td>
<td>14-14.5</td>
<td>88-90</td>
<td>1.2-1.5</td>
<td>70-71%</td>
<td>1.2-1.4</td>
</tr>
</tbody>
</table>

Table 5. Results after the installation of the fifth mill (2011-12 season).

<table>
<thead>
<tr>
<th>Cane crushed (t/d)</th>
<th>Fibre % cane</th>
<th>PI</th>
<th>First three-roller mill +GRPF (42”x84”)</th>
<th>Fifth two-roller mill +GRPF (50”x100”)</th>
<th>Reduced Mill Extraction (RME)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>kW/t/h</td>
<td>Average primary extraction (pol basis)</td>
<td>kW/t/h</td>
</tr>
<tr>
<td>8,500-9,500</td>
<td>14-14.5</td>
<td>88-90</td>
<td>1.2-1.5</td>
<td>70-71%</td>
<td>0.95-1.0</td>
</tr>
</tbody>
</table>

Table 6. Results after the installation of the zero mill (2014-15 season).

<table>
<thead>
<tr>
<th>Cane crushed (t/d)</th>
<th>Fibre % cane</th>
<th>PI</th>
<th>Zero two roller mill + GRPF (50”x100”)</th>
<th>Fifth two-roller mill +GRPF (50”x100”)</th>
<th>Reduced Mill Extraction (RME)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>kW/t/h</td>
<td>Average primary extraction (pol basis)</td>
<td>kW/t/h</td>
</tr>
<tr>
<td>12,500-13,500</td>
<td>14-14.5</td>
<td>90-92</td>
<td>1.3-1.5</td>
<td>79-80.5%</td>
<td>0.95-0.98</td>
</tr>
</tbody>
</table>

CONCLUSION

The new two-roller mill design has a simple construction, smaller footprint and has proved very reliable. It requires lower installed power, compared to an equivalent three-roller mill and gives higher primary extraction and a reduced bagasse moisture.

REFERENCES


Développement d’un moulin à canne à deux rouleaux et ses performances à l’Indian Canne Power Ltd, Karnataka, Inde

Résumé. L’Indian Canne Power Ltd (ICPL) a été créé en 2005 comme une sucrerie avec cogénération pour l’exportation d’énergie verte vers la grille. La capacité de l’usine était de 5000 t canne/j. Le tandem, comprenait quatre moulins conventionnels de trois-rouleaux, 107 cm x 214 cm, avec un rouleau d’entraînement sous-alimenté (UFR). Il a été progressivement agrandi pour broyer 12 500 t canne/j, en trois phases de 2011 à 2014. thyssenkrupp a proposé d’installer un design développé récemment comprenant des moulins avec deux rouleaux, dans l’espace limité disponible, pour atteindre la capacité ciblée de 12 500 t canne/j. Le premier moulin de deux rouleaux (127 cm x 254 cm) a été mis en service en 2011, comme dernier moulin. Il était doté de rouleaux rainurés d’alimentation sous pression (GRPF). Après avoir prouvé la bonne performance de la nouvelle conception, ICPL a installé un moulin semblable comme moulin zéro. Le nouveau moulin de deux rouleaux s’est avéré fiable pour broyer une haute capacité et a donné une performance satisfaisante. Le tandem a broyé
Desarrollo de un molino de caña de dos mazas y su desempeño en Indian Cane Power Ltd., Karnataka, India

Resumen. Indian Cane Power (ICPL) fue establecida en 2005 como una planta azucarera de cogeneracion para exportar energia verde a la red. La capacidad inicial de la planta fue de 5000 tcd. El tandem de molienda original, compuesto por cuatro molinos convencionales de tres mazas de 107 cm x 214 cm con una cuarta maza (UFR, por sus siglas en ingles), fue continuamente ampliado hasta 12.500 tcd en tres fases de 2011 a 2014. thyssenkrupp propuso instalar un molino de dos mazas de reciente diseño y desarrollo, en el limitado espacio disponible, para lograr la capacidad proyectada de 12.500 tcd. El primer molino de dos mazas de 127 cm x 254 cm entro en operacion en la zafra 2011 como ultimo molino. Fue suministrado con mazas de alimentacion forzada rayadas (GRPF, por sus siglas en ingles). Después de comprobar el buen desempeño del nuevo diseño, IPCL repitio la orden de compra por otro molino de las mismas características como molino cero. El nuevo diseño del molino de dos mazas ha demostrado ser confiable para manejar altas capacidades de molienda y ha proporcionado un desempeño satisfactorio. El ingenio ha molido aproximadamente 1.300.000 toneladas de caña en la zafra 2015-16 y IPCL tiene dos plantas de cogeneracion de 28 MW y 55 MW. Este trabajo documenta el desempeño y la experiencia operacional del reciente diseño y desarrollo de un molino de dos mazas en el ingenio de ICPL.

Palabras clave: Preparacion de caña, tipos de molinos, molino de dos mazas, industria azucarera de India