FE28: Enhancing Milling Efficiency and Throughput through control philosophy

SAN DIEGO EXPERIENCE

Speaker: D.K. Goel

ISGEC Heavy Engineering Ltd, India

At: 29th ISSCT Congress, Chiang Mai, Thailand, 5 December 2016
AUTHORS

Carlos Lopez
Ingenio Trinidad (Sandiego S.A) Guatemala
clopez@sandiego.com.gt

Kishor Bhosale
DGM- International Marketing
Isgec Heavy Engineering Limited
kishor91274@gmail.com
This paper highlights significance of the Control Philosophy and other features for enhancing the milling efficiency and throughput, by adopting:

- Multi set point control loops for individual mill.
- Integration of front end controls with that of the 1st mill.
- Differential Roll Speed.
- Improved system of mill roller grooving
BACKGROUND

San Diego SA, Guatemala recently replaced its existing milling tandem to enhance throughput as well as extraction efficiency. Front end i.e. fibrizor and cutter were retained.

The new tandem, supplied by ISGEC consists of five 1170 mm dia x 2134 mm (46 x 84 inch) size, 4-roll pinion-less mills.

It is designed for 454 t/h (500 short tons/h) and was commissioned in November 2014.
3D MODEL OF THE NEW 46 X 84 INCH MILL
## NEW MILLING TANDEM: SIZE AND DRIVE DETAILS

<table>
<thead>
<tr>
<th>Mill Size &amp; type</th>
<th>4-roll, 1170 mm Dia. x 2134 mm (46 x 84 Inch), pinionless mill</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Mills</td>
<td>5 Nos</td>
</tr>
<tr>
<td>Installed Power / mill</td>
<td></td>
</tr>
<tr>
<td>Top Roller</td>
<td>750 KW (Foot mounted)</td>
</tr>
<tr>
<td>Bottom rollers</td>
<td>300 KW each (Shaft mounted)</td>
</tr>
<tr>
<td>Top Roll Speed</td>
<td>6.17 RPM @ base speed of motor</td>
</tr>
<tr>
<td>Bottom Roll Speed</td>
<td>6.6 RPM @ base speed of motor</td>
</tr>
</tbody>
</table>
NEW MILLING TANDEM:
ACTUAL INSTALLATION

Foot Mounted Drive for top roller
NEW MILLING TANDEM: ACTUAL INSTALLATION

Shaft Mounted Drives at bottom rollers
KEY FEATURES
NEW MILLING TANDEM
KEY FEATURES:
2 TRASH PLATES

Additional trash plate between underfeed roll and cane roll to eliminate drop of cushion into juice tray.
KEY FEATURES:
SUPERIOR GRADE ROLLER SHELL

High strength Spheroidal Graphite Iron roller shell

SG Iron is 2.2 times stronger than conventional Cast Iron
KEY FEATURES:

IMPROVED NOZZLE PATTERN

1200 nozzles in top and bagasse rolls for quick drainage of juice.
KEY FEATURES:
ROLL GROOVES

Complete absence of chevron and Messchaert grooves to eliminate low compression area.

Tear drop arcing on tip of teeth to prevent slippage.
KEY FEATURES: DIFFERENTIAL ROLL SPEED

Assist drive with AC VFD to facilitate mill operations with differential roll speed.
KEY FEATURES: DCS BASED MILL AUTOMATION
NEW MILLING TANDEM:

WORKING RESULTS : FIRST SEASON 2014-15

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cane Crushed</td>
<td>1,660,000 tonnes</td>
</tr>
<tr>
<td>Average Crush Rate</td>
<td>401 TPH</td>
</tr>
<tr>
<td>RME</td>
<td>95.95%</td>
</tr>
<tr>
<td>Bagasse Moisture</td>
<td>48.5%</td>
</tr>
<tr>
<td>Pol in Bagasse</td>
<td>2.08%</td>
</tr>
<tr>
<td>Imbibition % on Cane</td>
<td>25.83%</td>
</tr>
</tbody>
</table>

Results fairly good but management felt scope of improvement. San Diego and Isgec team decided to analyze the data and finalize action plan for improvement.
FINDINGS AND CORRECTIVE ACTIONS
1st mill was controlled by belt weigher, leading to very wide fluctuations in torque which adversely affected the primary extraction.

The cane feed from the conveyor was not integrated with the mill controls. The fluctuations experienced in the first mill that were attributed to cane feed were eventually observed in the subsequent mills.

Mill speed was governed by two set points, one for torque and other for Donnelly chute level. Mill speed was always seeking to meet these two criteria leading to hunting.

Prevalent Control philosophy not conducive for fluctuations in cane feeding
<table>
<thead>
<tr>
<th>Existing for 2014-15</th>
<th>Modified for 2015-16</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conventional Philosophy</strong></td>
<td><strong>Advanced Philosophy</strong></td>
</tr>
<tr>
<td>1. Single point control of Belt feeding the first mill by cane belt weigher.</td>
<td>Control through Belt weighing eliminated. Data used for monitoring only.</td>
</tr>
<tr>
<td>2. Cane feed from conveyor not integrated with mill controls.</td>
<td>Cane feed from conveyor integrated with 1st mill top roll drive load. 1st mill top roll speed pre-set to match with desired crush rate. Cane carrier speed is regulated in proportion to D-chute level.</td>
</tr>
<tr>
<td>Control Philosophy</td>
<td>Conventional Philosophy</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td><strong>Existing for 2014-15</strong></td>
<td>Mill speed governed by two set points, one for torque and one for D-chute levels.</td>
</tr>
<tr>
<td><strong>Modified for 2015-16</strong></td>
<td></td>
</tr>
</tbody>
</table>
CONTROL PHILOSOPHY FOR 1ST MILL : 2015-16

• Multi set points for donnelly chute, to govern the speed of the cane carrier.

• In case of very low level in D-chute, an alarm shall be raised for operator to change crush rate setting.

Speed set points for different crush rate for 1st mill

<table>
<thead>
<tr>
<th>Crushing rate (t/h)</th>
<th>350</th>
<th>400</th>
<th>450</th>
<th>475</th>
<th>500</th>
<th>525</th>
<th>550</th>
<th>575</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top roll speed (rpm)</td>
<td>3.8</td>
<td>4.4</td>
<td>4.9</td>
<td>5.2</td>
<td>5.4</td>
<td>5.7</td>
<td>6.0</td>
<td>6.2</td>
</tr>
</tbody>
</table>
CONTROL PHILOSOPHY
FOR 1ST MILL : 2015-16

Prepared cane carrier speed vs 1st Mill D-chute level

<table>
<thead>
<tr>
<th>D-chute sensor</th>
<th>L-1 (no level)</th>
<th>L-2</th>
<th>L-3</th>
<th>L-4</th>
<th>L-5</th>
<th>L-6</th>
<th>L-7 (high)</th>
<th>L-8 (high high)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-chute level (%)</td>
<td>0</td>
<td>12</td>
<td>25</td>
<td>37</td>
<td>50</td>
<td>62</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Conveyor speed (%)</td>
<td>100</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>60</td>
<td>50</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

Override signals details for Mill Control for 1st Mill

<table>
<thead>
<tr>
<th>Override controls</th>
<th>Mill motor load high</th>
<th>No Donnelly chute level</th>
<th>Donnelly Chute level high</th>
<th>Screened Juice tank level low</th>
<th>Screened Juice tank level high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal</td>
<td>Lower conveyor speed</td>
<td>Conveyor speed to maximum</td>
<td>Conveyor speed to zero</td>
<td>Increase conveyor speed</td>
<td>Conveyor speed to minimum</td>
</tr>
</tbody>
</table>
CONTROL PHILOSOPHY: FOR 2ND-5TH MILL : 2015-16

- Speed of 2nd and subsequent mills shall be governed by top roller drive load through 8 set points.
- D-chute level shall provide override signals to speed up/slow down the mill

<table>
<thead>
<tr>
<th>Top Roll load (A)</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>85</th>
<th>90</th>
<th>100</th>
<th>115</th>
<th>129</th>
</tr>
</thead>
<tbody>
<tr>
<td>(rpm)</td>
<td>5.48</td>
<td>5.57</td>
<td>5.65</td>
<td>5.74</td>
<td>5.82</td>
<td>6.00</td>
<td>6.08</td>
<td>6.17</td>
</tr>
<tr>
<td>D-chute level (%)</td>
<td>0</td>
<td>12</td>
<td>25</td>
<td>37</td>
<td>50</td>
<td>62</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

Override controls:
- No Donnelly chute level
- Donnelly chute level high
- Inter-carrier trip

Signal:
- Top roller speed to minimum
- Top roller speed to maximum
- Trip all the preceding carriers
DIFFERENTIAL ROLL SPEED RATIO: 2015-16

- Initially top to baggase roll ratio (Rb) set at 1.02
- While top to cane roll ratio (Rc) set at 1.03
- After observing mill working, speed ratios fine tuned as per following table, to avoid any of the drive from overloading.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>Rb</td>
<td>R</td>
</tr>
<tr>
<td>1</td>
<td>0.985</td>
<td>0.935</td>
<td>1.03</td>
</tr>
<tr>
<td>2</td>
<td>0.985</td>
<td>0.935</td>
<td>1.03</td>
</tr>
<tr>
<td>3</td>
<td>0.985</td>
<td>0.935</td>
<td>1.03</td>
</tr>
<tr>
<td>4</td>
<td>0.985</td>
<td>0.935</td>
<td>1.03</td>
</tr>
<tr>
<td>5</td>
<td>0.985</td>
<td>0.935</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Top Roll kept at higher surface speed than bottom rolls except 2nd mill
Achieved narrow band of fluctuations in load and speed

Typical DCS trend of bagasse roll of Mill no. 1
WORKING RESULTS

2015-16: MILL 2 TO MILL 5

- Uniform feed from 1st mill passed on to subsequent mills.
- Stable load and speed in all subsequent mills.

Typical DCS trend of bagasse roll of Mill no. 3
CONTROL PHILOSOPHY

RESULTS: BEFORE/AFTER

- Date of start of season 2015-16: 20 Nov 2015
- Date of implementation of new Control philosophy: 02 Dec 2015

<table>
<thead>
<tr>
<th>Date</th>
<th>RME (%)</th>
<th>Bagasse Pol (%)</th>
<th>Bagasse moisture (%)</th>
<th>Imbibition % cane</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Dec 2015</td>
<td>96.28</td>
<td>1.92</td>
<td>47.90</td>
<td>26</td>
</tr>
<tr>
<td>29 Dec 2015</td>
<td>97.45</td>
<td>1.21</td>
<td>47.11</td>
<td>27</td>
</tr>
</tbody>
</table>

After implementation of new control philosophy, there was sharp reduction in bagasse Pol and moisture.


<table>
<thead>
<tr>
<th>Parameter</th>
<th>2014-15</th>
<th>2015-16</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cane crushed, tonnes</td>
<td>1,660,455</td>
<td>2,103,940</td>
<td>26 %</td>
</tr>
<tr>
<td>Crop average, pol % cane</td>
<td>13.03</td>
<td>12.73</td>
<td></td>
</tr>
<tr>
<td>Average cane crushing per crop day, t/d</td>
<td>9,630</td>
<td>12,135</td>
<td>26 %</td>
</tr>
<tr>
<td>Average crush rate, t/h</td>
<td>401</td>
<td>505</td>
<td>26 %</td>
</tr>
<tr>
<td>Imbibition water % cane</td>
<td>25.83</td>
<td>27.42</td>
<td>6 %</td>
</tr>
<tr>
<td>Bagasse Pol, %</td>
<td>2.08</td>
<td>1.58</td>
<td>32 %</td>
</tr>
<tr>
<td>Bagasse moisture, %</td>
<td>48.49</td>
<td>48.16</td>
<td>1 %</td>
</tr>
<tr>
<td>RME, %</td>
<td>95.95</td>
<td>96.92</td>
<td>1 %</td>
</tr>
</tbody>
</table>

Throughput improved by 26% and mill extraction efficiency improved by 1%
2400 tonnes additional sugar, worth 1.2 million dollars, produced during 2015-16 due to improved milling efficiency
### SEASON-WISE COMPARISON: ROLL POWER SHARING

Power sharing between rolls during 2014–15 Vs 2015-2016

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cane crushed: 10,407 t</td>
<td>Cane crushed: 13,457 t</td>
</tr>
<tr>
<td>AMP, kW, Surface speed ratio</td>
<td>AMP, kW, Surface speed ratio</td>
<td></td>
</tr>
<tr>
<td>Top roll</td>
<td>Top roll AMP: 83, kW: 389, ratio: 100</td>
<td>Top roll AMP: 78.5, kW: 407.8, ratio: 100</td>
</tr>
<tr>
<td>Cane roll</td>
<td>Cane roll AMP: 376, kW: 194, ratio: 98.34</td>
<td>Cane roll AMP: 330.6, kW: 184.8, ratio: 103</td>
</tr>
<tr>
<td>Bagasse roll</td>
<td>Bagasse roll AMP: 385, kW: 190, ratio: 93.41</td>
<td>Bagasse roll AMP: 488.7, kW: 287.4, ratio: 102</td>
</tr>
</tbody>
</table>
• Multi set point control philosophy stabilizes the cane feed, thereby improving throughput by upto 25%.

• This also helps in operating the drives over a narrow band of torque and speed, eliminating hunting mode.

• It helps to improve the milling efficiency without having to alter the basic configuration of mills.

• Fine tuning of the roll speed ratio can increase RME by one percentage and reduce bagasse moisture by half percentage point.
Thank You

Presented By

Isgec Heavy Engineering Ltd, Noida, India