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Improvement in Mill Capapcity and Performnace by Installation of Higher Size Underfeed Roller and Grooved Roller Pressure Feeder

P.R. Ghundre*, Ravi Srivastava, Prashant Chaudhary and A. Mishra
Balrampur Chini Mills Ltd., Balrampur, Uttar Pradesh

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ABSTRACT

The diameter and peripheral speed of the grooved roller pressure feeder (GRPF) and under feed roller (UFR) on a six-roller mill, as a percentage of the mill roller, has a great influence on the capacity and efficiency of the mill. The capacity increases, mainly due to an increase in the peripheral speed and an increase in the allowable width of a Donnelly chute, due to increases in the GRPF and UFR diameters. The bulk density of prepared cane in a Donnelly chute is fundamentally constant for a given Preparation Index (PI) of cane. Accordingly, a larger allowable Donnelly-chute opening, and a higher peripheral speed increase the throughput capacity of a mill, other things being equal. The mill capacity also increases due to the improved feedability of the UFR as the contact arc with the bagasse blanket increases. An increased arc of contact reduces the possible slip during cane feeding. Increasing the UFR arc of contact allows it to operate at a higher speed relative to the other rollers. This increases the density at the feed opening entry, resulting in improved extraction at the feed nip and reducing the juice load on the discharge side of the mill. Greater GRPF and UFR diameters increase the capacity of the mill at the same operating speed, or the mill can operate at reduced speeds for the same crush capacity with an improved extraction level. This paper highlights the results achieved in two sugar mills in India for increasing the crushing capacity from 9000 to 11000 t cane/day in Balrampur Chini Mills Ltd; Kumbhi unit by installing a higher diameter GRPF and UFR (GRPF PCD 20% higher and UFR PCD 25% higher than mill roller PCD) and achievement of mill crush capacity of 9000 TCD with improved mill performance by installation of higher size UFR (25% higher PCD than mill roller PCD) at Balrampur Chini Mills Ltd. Babhnan unit.

Keywords: Higher size grooved roller pressure feeder (GRPF), higher size underfeed roller (UFR), mill capacity, mill performance; pitch circle diameter (PCD).

INTRODUCTION

Balrampur Chini Mills Ltd; (BCML) Babhnan Unit was operating with two milling tandems to crush 8000 TCD. BCML management had decided to dismantle both milling tandem and replace it by new single milling tandem comprises of five mills of size Ø1067x2135 mm long with GRPF installed at Mill # 1 and Mil # 5. All mills were installed with higher size Underfeed roller having PCD 25 % higher than mill roller PCD. GRPF PCD is equal to mill roller PCD.

Dismantling of both existing milling tandem and installation of new single milling tandem was carried in offseason 2022(April to November 2022) . New milling tandem supplied and erected by Indian Sugar and General Engineering Company (ISGEC); Noida was commissioned in November 2022.

Encouraging results were achieved with higher size UFR installed at Babhnan unit.

Balrampur Chini Mills Ltd; Kumbhi unit is having milling tandem comprises of five mills of size Ø1067x2135 mm long with GRPF installed at Mill # 1 and Mill # 5. (GRPF PCD and TUFR PCD equal to mill roller PCD). Existing Mill Capacity is 8500 TCD.

*Corresponding Author email: prashant.ghundre@bcml.in

BCML management had decided to increase the crush capacity of factory to 11000 TCD. Higher size GRPF (GRPF PCD 20% higher than mill roller PCD) with higher size GUFR (GUFR PCD-25%higher than mill roller PCD) was installed at Mill # 1,2,5. Existing GRPF at Mill # 1 was installed /relocated at Mill # 3 and Existing GRPF at Mill # 5 was installed/ relocated at Mill #4. All mills were installed with higher size GUFR. Modification work carried out in offseason 2023 (April to November 2023) and successfully commissioned in November 2023. Peak crushing achieved is 11500 TCD. Installation of higher size GRPF and other modification work were carried out by Uttam Industrial and Engineering Pvt. Ltd. (Ghaziabad)

Technology concept: influence of GRPF and UFR roller diameters

The diameter and peripheral speeds of the GRPF and UFR, as a percentage of the mill roller, has a great influence on the capacity and efficiency of the mill. Garson (2008) mentions that throughput of the mill for a given material and feeding conditions will be proportional to the length of the mill rolls, the diameter of the mill rolls and the linear surface speed of mill rolls.

Formula for three-roller mill fed with UFR:

$$\frac{\rho x H x \cos(\theta) x \left(\frac{\pi x \frac{D}{1000} x n + \pi x \frac{DUFR}{1000} x n1}{2} \right) x \frac{L}{1000} x 60}{f x 1000 x 1000} \qquad \text{Formula 1}$$

where: ρ = density of material in a Donnelly chute in kg/m^3; H = Donnelley chute opening in mm; θ = Donnelley chute contact angle; D = mill roller pitch circle diameter (PCD) in mm; n = roller speed in r/min; DUFR = UFR PCD in mm; n^1 = UFR speed in r/min; L = roller length in mm; f = fibre% of cane.

Formula for three-roller mill fed with GRPF and UFR:

$$\frac{\rho x H x \cos(\theta) x \left(\frac{\pi X \frac{DGRPF}{1000} X n2 + \pi X \frac{DUFR}{1000} X n1}{2} \right) x \frac{L}{1000} x 60}{f x 1000 x 1000} \qquad \text{Formula 2}$$

where: ρ = density of material in Donnelly chute in kg/m^3; H = Donnelley chute opening in mm; θ = Donnelley chute contact angle; DGRPF = GRPF PCD in mm; n^2 = GRPF speed in r/min; DUFR = UFR PCD in mm; n1 = UFR speed in r/min; L = roller length in mm; f = fibre% of cane.

Case A : Installation of higher size GUFR at Babhnan unit

Table 1 : Mill performance data for 9000 TCD crush rate

Crushing TCH					
Date 08/01/2023	375				
Total Crushing -TCD /24 hrs	9000				
Fibre % cane	16.19				
Pol % cane	13.16				

Cane Preparation					
	Installed power	#knives /hammers	Full load current in ampere	Operating load current in ampere	Clearance
Chopper on ACC	1 X 187 KW	54 nos.	341 Amp	170 A	650
HOC on ACC	2 X 300 KW	72 nos.	585 Amp	309 A, 312 A	450
Chopper on MCC	2 X 265 KW	54 nos.	469 Amp	162 A, 171 A	795
Leveller on MCC	2 X 500 KW	72 nos.	35 Amp	20 A, 21 A	305
Fibrizor on MCC	2 X 1500 KW	192 nos.	103 Amp	51 A, 52 A	Inlet 190/ Outlet-20mm
Power Consumption for Total Cane Preparation kW/TFH	44.47				
	Mill #1	Mill #2	Mill #3	Mill #4	Mill #5
Installed Power – kW	900	900	900	900	900
Mill Full speed @ rated speed of prime mover	4.50	4.50	4.50	4.50	4.50
Average of top and discharge roller pcd – mm	1096.70	1096.70	1096.70	1105.80	1105.80
Roller Length –mm	2135				
GUFR pcd -mm	1334.10	1319.70	1319.70	1332.40	1334.10
Mill operating rpm (average of 24 hrs)	3.830	3.585	3.584	3.570	3.161
Mill operating peripheral speed – mtr/minute	13.18	12.34	12.34	12.39	10.97
Milling tandem average peripheral speed	12.34				
Power Consumed – kW/TFH	10.93	11.26	11.34	11.30	10.96
Top roller lift(average)	12	12	10	12	10
Hydraulic pressure applied in kg/cm^2	185	190	190	190	195
GRPF -pcd – mm	1094.10				1094.10
GRPF – Installed power -kW	400				400
GRPF operating speed % -GRPF /mill peripheral speed %	120				115
GRPF Power consumption -KW/TFH	4.65				4.94
PI	>90				
Pol % bagasse	1.39				
Moisture % bagasse	46.77				
RME (Noel Deerr)	97.54				

Crushing season (2022-2023) and season 2023-24 average data .

Table 2 : Average crushing season – mill performance data

Sr #	Description	Season 2022-23	Season 2023-24
1	Average cane crushed -TCH /TCD	341/8186	336.12/8067
2	Pol % cane	13.68	13.72
3	Fibre % cane	16.80	16.81
4	Imbibition % fibre	324.58	322.43
5	Pol % Bagasse	1.40	1.38
6	Moisture % bagasse	47.31	46.97
7	RME (Noel deer)	97.60	97.68

Case B : Installation of higher size GUFR at Babhnan unit

Table 3 : Mill performance data for 11000 TCD crush rate

Crushing TCH	460.83				08/02/2024
Total Crushing -TCD / 24 hours	11059.92				
Fibre % cane	12.99				
Imbibition % fibre	331.64				
Cane preparation					
	Installed power	#knives /hammers	Full load current in ampere	Operating in load current in ampere	Clearance
Chopper on ACC	1 X 375 KW	60 nos.	742	447 A	780
HOC on ACC	2 X 375 KW	60 nos.	706 Amp	431 A, 384 A	500
Chopper on MCC	2 X 220 KW	60 nos.	365 Amp	152 A, 146 A	770
Leveller on MCC	2 X 600 KW	64 nos.	44 Amp	26 A, 27 A	320
Fibrizor on MCC	2 X 1750 KW	172 nos.	116 Amp	78 A, 75 A	Inlet 200 mm, 22 at disch.
Power Consumption for Total Cane Preparation kW/TFH	60.20				
	Mill#1	Mill #2	Mill #3	Mill#4	Mill #5
Installed Power - KW	1000	750	750	750	750
Mill Full speed @rated speed of prime mover	5.13	4.38	4.38	4.38	4.38
Average of top and discharge roller pcd – mm	1068	1064	1061	1100	1082
Roller Length- mm	2135				
GUFR -pcd -mm	1345	1345	1345	1358	1358
Mill operating speed -rpm	4.20	3.90	3.94	3.95	3.90
Mill operating peripheral speed – 14.09 mtr/minute	13.03	13.13	13.65	13.25	
Milling tandem average peripheral speed – mtr/minute	13.43				

Power consumed – kW/TFH	8.50	7.81	8.77	8.90	8.69
Top roller lift(average)	9	9	9	7	8
\Hydraulic ram dia	430 mm	430 mm	430 mm	430 mm	430 mm
Hydraulic pressure applied in kg/cm^2	175	175	175	175	180
GRPF pcd	1296	1296	1065.50	1095	1313
GRPF – installed power kw	600 KW	600 KW	400 KW	400 KW	750 KW
GRPF operating speed %. GRPF/mIll peripheral speed %	120	120	120	120	120
GRPF Power consumption -kW/TFH	5.55	5.76	3.75	3.94	5.60
PI	90.55				
Pol % cane	13.66				
Pol % bagasse	1.39				
Moisture % bagasse	47.51				
RME (Noel Deerr)	97.50				

Table 4 : Average crushing season – Mill performance data - season 2022-23 (before modification) and season 2023-24 (after modification)

Sr #	Description	Season 2022-23	Season 2023-24
1	Average cane crushed -TCH /TCD	341/8186	336.12/8067
2	Pol % cane	13.68	13.72
3	Fibre % cane	16.80	16.81
4	Imbibition % fibre	324.58	322.43
5	Pol % Bagasse	1.40	1.38
6	Moisture % bagasse	47.31	46.97
7	RME (Noel deer)	97.60	97.68

RETURNS

- A higher size diameter UFR (25% higher than mill roller) increases the mill crushing capacity by 15-20% relative to a UFR of the same diameter as the mill rollers.
- The capacity increases mainly due to increase in allowable width of the Donnelly chute and the peripheral speed increase due to an increase in the UFR diameter. As the density of prepared cane in a Donnelly chute is broadly constant for the available PI of cane, a higher allowable Donnelly chute opening and an increase in the peripheral speed increaseincreases the throughput capacity of the mill.
- The peripheral speed% of the UFR to the mill can be further increased, provided the geometry of the UFR with respect to the top roller centre is maintained properly.
- The capacity also increases due to the improved feedability of the UFR as the contact arc with the bagasse blanket increases. The increase in the arc of contact reduces any possible slip during cane feeding.
- The increase in the UFR arc of contact allows operation of the UFR at a higher speed, which increases the density at the feed opening entry, resulting in improved extraction at the feed opening and reducing the juice load on the discharge side.

- A higher UFR diameter increases the capacity of the mill at same operating speed, or the mill can operate at reduced speeds for the same crush capacity with improved extraction.
- Higher size GRPF (20% higher size than mill roller PCD) with higher size GUFR (25%higher size than mill roller PCD) increases the crush capacity by around 22%. W with improved mill performance.

CONCLUSIONS

Case study A:

- Installation of a 25% higher diameter UFR on all mills increased the crush capacity.
- Installation of a 25% higher diameter UFR allowed operation of the mills at a lower speed.
- RME achieved -97.68 and moisture% bagasse -46.5.

Case study B:

- Installation of 20% higher diameter GRPF and 25% higher size UFR on Mills #1, #2, #5 and installation of 25% higher diameter GUFR on Mill #3,4 increased the crush capacity from 9000Tons cane/day to 11000-11500 tons cane/day.
- RME was improved and moisture% bagasse was reduced.

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