



## Effects of feed particle size distribution and chemical properties on roller press performance and comminution efficiency at plants 7 and 8 of PT Indocement Tunggal Prakarsa, Tbk

Mubarokah N Dewi\*, Dwi Qurningsih, Samuel Armawan Sandi, Dody Guntama, Lukman Nulhakim, Lubena, Irma Agustin

Department of Chemical Engineering, University of Jayabaya, Jakarta 16452, Indonesia

\*Corresponding author: mubarokah.n.dewi@gmail.com

### Abstract

Roller press is a comminution machine that works based on contact force and compression force at high pressure. Several operational constraints, such as hydraulic pressure, can cause the roller press feed to malfunction, leading to performance degradation. This study aims to analyze the effect of material feed characteristics on roller press performance in the finish mill unit of PT. Indocement Tunggal Prakarsa, Tbk. The methods used include Particle Size Distribution (PSD) analysis, free lime test, tricalcium silicate ( $C_3S$ ), and Work Index (WI) testing on samples from clinker plant 7 (P7) and plant 8 (P8). Roller press operational parameters hydraulic pressure, and grinding pressure, were analyzed to spread the impact of particle size distribution on comminution efficiency. The results showed that optimal roller press performance was achieved when the PSD material was evenly distributed with  $f_{80}$  of 12.98 mm and a reduction ratio of 8.16. The specific grinding power required was 5.33 N/mm<sup>2</sup> with a power consumption of 6.92 kWh/t. In addition, clinker with  $C_3S$  content of 62.53% and free lime of 1.25% had better grind-ability, with WI value of 12.90 kWh/t, which contributed to a comminution efficiency of 12.50%. The conclusion of this study is that the particle size distribution of feed material greatly affects the operational parameters of roller press and energy efficiency. Material with more even size distribution and better grind-ability results in more effective comminution performance and lower energy consumption, which has implications for improving the efficiency of grinding process in the cement industry.

### Keywords:

Comminution efficiency, particle size distribution, clinker, roller press.

### 1 Introduction

Mineral processing consumes the largest share of electricity generated worldwide, with about 4% of global electricity consumed by mineral processing plants. About 80% of this is used for crushing and grinding raw materials [2]. One alternative comminution technology that has been widely applied to save energy is high-pressure grinding rolls or commonly known as roller presses [3] [4] [5]. The use of High Pressure Grinding Roll (HPGR) with various circuit configurations has been developed for energy-efficient comminution.

The energy savings achieved using HPGR compared to conventional comminution performed on Platreef samples varied from 10% to 30% [6]. HPGR has been proven to increase production capacity and reduce energy consumption [7]. The use of HPGR in various alternative circuits has lower energy consumption

compared to ball milling technology [8]. However, due to the micro cracks created by the very high compression forces in the particle layer, the Bond Working Index of the material is reduced for subsequent grinding operations [9] [10]. The high pressure roll milling capability has been proven to ignite a variety of materials, including lead, cement clinker, dolomite, and coal [11]. It is true, the Bond Work Index (BWI) of HPGR products is claimed to be much lower than conventional crusher products [12] [13].

The finishing mill utilized in this study is a roller press configuration system, functioning as a semi-finish grinding process for the production of Ordinary Portland Cement (OPC). In this system, the grinding of blended materials—comprising clinker, additives, gypsum, and limestone—occurs entirely within the roller press unit. The roller press operates based on the contact force between feed particles and the compressive force applied under high pressure. This high pressure induces the formation of micro-cracks in the feed particles, leading to the generation of a substantial amount of fine material [9].

Under actual operating conditions, several challenges may arise, including the accumulation of fine materials on transport equipment, hydraulic pressure surges, and other factors that may necessitate the temporary shutdown of the roller press feed. One significant cause may originate from the feed material itself, particularly clinker, which constitutes the largest proportion of the input. This situation can lead to reduced performance of the roller press, thereby significantly impacting both the quality and quantity of the final product in the finish mill unit [14] [15].

Analysis of feed material characteristics can be conducted by evaluating several testing parameters that encompass both physical and chemical properties. The primary physical property is Particle Size Distribution (PSD), while the chemical properties include the content of tricalcium silicate ( $Ca_3SiO_5$  or  $C_3S$ ) and free lime in the raw materials. Additionally, the Work Index (WI) of clinker is a crucial factor, as it reflects the relationship between chemical composition and the grind-ability of the material.

From both technological and economic perspectives, two main aspects must be addressed to enhance the effectiveness of comminution equipment: the characteristics of the feed material and the key process parameters. These parameters include hydraulic pressure, separator speed, product quality, energy consumption, and production capacity, all of which are critical in determining the overall efficiency and performance of the comminution system [16]. Therefore, an in-depth analysis of raw material characteristics is essential to assess their impact on roller press performance.

Although HPGR are widely used in the cement industry, there remains a significant gap in understanding the direct relationship between specific material properties such as PSD and chemical composition and the operational performance of roller presses under real industrial conditions. Previous studies [8] [9] [10] have generally compared different grinding technologies under controlled conditions, without fully accounting for variability in feed characteristics across different plants or the practical challenges faced in actual industrial operations.

Moreover, while many studies focus on general grinding efficiency, research specifically investigating the influence of material composition, particularly clinker characteristics, on grind-ability and energy consumption in roller press machines remains limited [6] [14]. This study aims to address this gap by providing a comprehensive analysis of the impact of feed characteristics on roller press performance at PT Indocement Tunggal Prakarsa, Tbk, offering new insights into how plant-specific feed variability can be leveraged to optimize grinding efficiency and energy utilization.

### 2 Research methodology

The operational parameter data were used as supporting data and processed together with the test results to obtain the desired variables. These data were collected through monitoring records from the Continuous Casting and Rolling (CCR) unit of Finish Mill

8B at plant 8 (sample 1) and plant 7 (sample 2). Both the test results and operational data were compiled and presented in the form of tables and graphs. Calculations were carried out using equations referenced from relevant literature.

The dependent variables in this study include the quality and quantity of the roller press grinding product, operational parameters of the roller press, energy efficiency or comminution efficiency of the roller press unit.

The controlled variables maintained during the data collection process: (1) sliding gate opening was maintained at 87.50%; (2) damper of dust collector 1402 was maintained at 64.00% open; (3) sepol 1 speed was maintained at 281 rpm.

The primary data were obtained through direct investigation of the research object, including feed material characteristics such as particle size distribution, chemical composition of the clinker, and the work index, which were obtained through testing at the Process Control Laboratory (PCL) 6-11.

## 2.1 Sample collection point determination

Material samples were taken from each designated sampling point using a shovel, with approximately  $\pm 1000$  grams collected for material characterization testing. Fig. 1 (right) shows the sampling process of clinker from the weighing feeder clinker, while Fig. 1 (left) shows the sampling of limestone from the weighing feeder limestone.



Fig. 1. Sample collection at the weighing feeder material feed (left: WF clinker – right: WF limestone).

Meanwhile, there are eight sampling points involved in this study, as illustrated in Fig. 2. The description of each point is: (1) point 1, clinker weighing feeder; (2) point 2, gypsum weighing feeder; (3) point 3, additive weighing feeder; (4) point 4, roller press output; (5) point 5, air slide 29001 (sepol 1 product); (6) point 6, air slide 290201 (dust collector product); (7) point 7, belt conveyor 1501 (roller press tailing); (8) point 8, air slide 29011 (final product of roller press circuit).

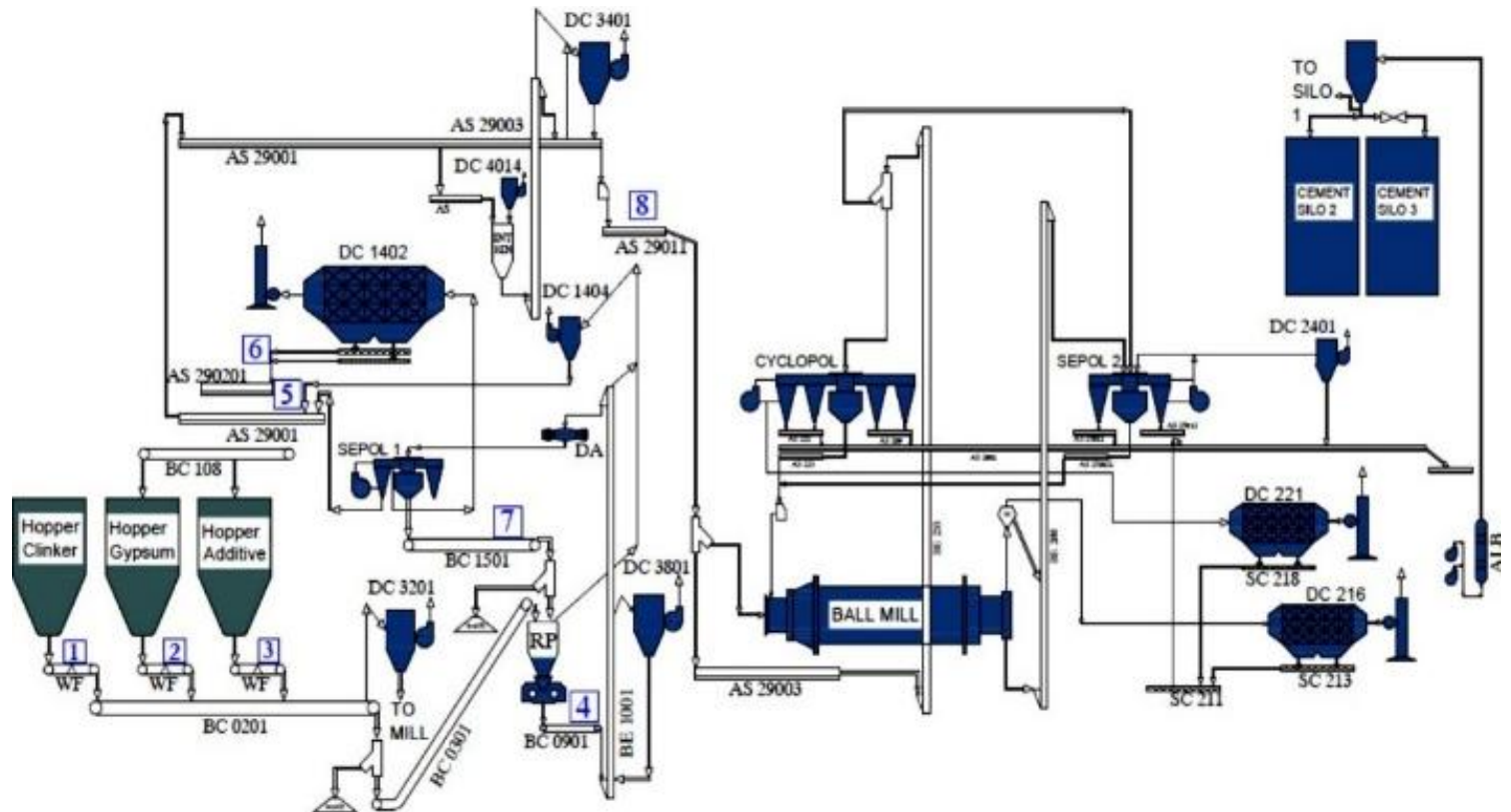


Fig. 2. Finish mill unit of plant 7 and plant 8 at PT Indocement Tunggal Prakarsa, Tbk.

## 2.2 Data collection and parameter measurement

### 2.2.1 Working gap, hydraulic pressure, and grinding pressure

These parameters were recorded directly from the roller-press control panel (DCS system) during stable operational periods at plants 7 and 8. The working gap was measured using the press roller displacement sensors, while hydraulic and grinding pressures were monitored from the hydraulic circuit readings and process log data.

### 2.2.2 Reduction ratio and grinding efficiency

Feed and product particle size distributions were determined using the sieve analysis method in accordance with ASTM C136. The reduction ratio ( $n$ ) was calculated as  $F_{80}/P_{80}$ , while grinding efficiency was derived from the ratio of theoretical to actual energy consumption based on Bond's equation.

### 2.2.3 Grind-ability and comminution efficiency

Grind-ability was measured using the BWI test following ASTM C348-02. Clinker samples were ground in a standard ball mill under controlled conditions. Comminution efficiency was then calculated as the ratio between theoretical (Bond) and actual roller-press energy consumption per tonne of material processed.

## 2.3 Analysis

Several test samples were analyzed in this study, including: PSD test and work index test.

### 2.3.1 PSD test

The method follows ASTM D-1921 using sieves with mesh sizes of 64 mm, 32 mm, 16 mm, 8 mm, 4 mm, 2 mm, and 1 mm.

The material sample (typically 100 g) was shaken, vibrated, or tapped through the sieves for 3 minutes [17].

### 2.3.2 Work index test

The work index is one of the indicators of grind-ability. The work index can be calculated using the Eq. (1) [18], where  $BW_i$  is bond work index (kWh/ton),  $P_i$  is test sieve size ( $\mu\text{m}$ ),  $G_{PR}$  is grind-ability (g/rev),  $P_{80}$  is 80% passing size of product ( $\mu\text{m}$ ),  $F_{80}$  is 80% passing size of feed ( $\mu\text{m}$ ), 44.5 is empirical constant for standard Bond test ball mill, 1.103 is conversion factor to adjust from metric to specific test condition.

$$BW_i = \frac{44.5}{P_i^{0.23} \times G_{PR}^{0.82} \times \left( \frac{10}{\sqrt{P_{80}}} - \frac{10}{\sqrt{F_{80}}} \times 1.103 \right)} \quad (1)$$

## 3 Results and discussion

### 3.1 Feed-PSD test results

Fig. 3 shows the PSD test results of the feed materials using sieve analysis for sample 1 and sample 2. Based on the available data, the particle size distribution was analyzed using a cumulative base curve to determine the relationship between particle size (in mm) and cumulative passing percentage (amount passing through the sieve), along with statistical parameters.

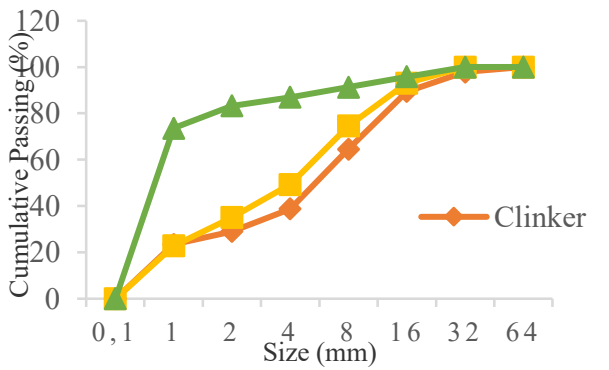


Fig. 3. PSD analysis diagram of feed-sample 1.

Fig. 3 illustrates that gypsum exhibits a steeper trend line compared to clinker and limestone, signifying a narrower particle size distribution. This is evidenced by a cumulative passing percentage of 73.60% on the 1 mm sieve, indicating that the majority of gypsum particles are smaller than 1 mm. In contrast, clinker and limestone display a more uniform particle size distribution, with the passing percentage gradually increasing as particle size increases.

The narrower particle size distribution of gypsum suggests that this material contains a higher proportion of fines compared to clinker and limestone. This characteristic can influence the grinding process in a roller press, as smaller particles are generally easier to grind. However, a heterogeneous particle size distribution may lead to imbalances in the comminution process, adversely affecting grinding efficiency.

Moreover, clinker and limestone in Sample 1 exhibit a broader particle size distribution range, encompassing fine, medium, and coarse particles in more balanced proportions. This suggests that both materials possess more stable characteristics during the comminution process, which can enhance the grinding efficiency of the roller press. Conversely, the presence of significantly smaller gypsum particles may negatively impact pozzolanic activity and workability in cement production.

In conclusion, a more homogeneous particle size distribution, as demonstrated by clinker and limestone, is preferable for maintaining a stable grinding process. Conversely, the presence of materials with a higher proportion of finer particles, such as gypsum, should be carefully controlled to prevent disruptions to comminution efficiency. Correlating with the statistical parameter

data in Table 1, gypsum has the highest particle frequency at <1 mm, with a median value of 0.71 mm and a mean of 2.47 mm. Therefore, this indicates that gypsum contains a greater number of small particles (fine grains) and dominates, resulting in an uneven particle size distribution. This will impact pozzolanic activity, workability, and other important related qualities [19].

Table 1. Statistical parameters of sample 1

Parameter	Material size (mm)		
	Clinker	Limestone	Gypsum
Mode	4	4	< 1
Median	5.75	4.11	0.71
Mean	8.09	6.14	2.47

The clinker and limestone materials in sample 1 indicate a relatively broad particle size distribution. This is due to the statistical data values for both materials falling within the medium particle size range, resulting in a uniform distribution across fine, medium, and coarse particles.

Fig. 4. illustrates that clinker and limestone exhibit a relatively broad particle size distribution, encompassing a range from fine to coarse particles. However, a detailed examination of the distribution curves and the associated statistical data indicates that clinker has the highest particle size frequency at 8 mm, with a median of 7.93 mm and a mean of 12.01 mm. This suggests that the particles in sample 2 of clinker are generally coarser than those of the other materials.

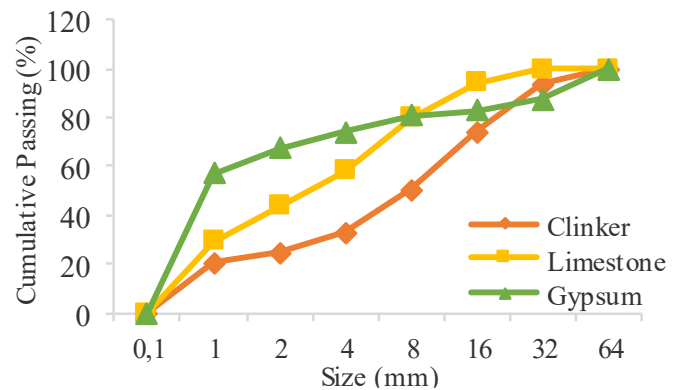


Fig. 4. PSD feed analysis diagram-sample 2

In contrast, limestone displays a more uniform PSD, ranging from fine to medium. This uniformity signifies that limestone particles are more consistent in size compared to clinker, which tends towards coarser particles. Conversely, gypsum demonstrates a steeper distribution trend, characterized by a higher proportion of smaller particles, consistent with the analysis results for sample 1.

The implication of this difference in particle size distribution is that clinker with larger particle sizes requires higher grinding energy during the comminution process. Conversely, limestone, with a broader particle size distribution, tends to be easier to grind than clinker. A particle size distribution that is too large or too small can affect the efficiency of the grinding process, ultimately impacting energy consumption and the quality of the final product.

Therefore, controlling the particle size distribution during the feed process is crucial for improving grinding efficiency, particularly in roller press operations. A size distribution that is too coarse can lead to decreased comminution efficiency, while a more balanced distribution (as in limestone) is desirable for improving overall grinding performance.

Based on the statistical analysis of material size in sample 2, the PSD for clinker, limestone, and gypsum shows distinct characteristics. Clinker has larger particle sizes compared to limestone and gypsum, with a mode of 8 mm, a median of 7.93 mm, and a mean of 12.01 mm. This indicates that most clinker particles fall within a coarser size range, which requires higher grinding energy during the comminution process (Table 2).

Table 2. Statistical parameters of PSD for clinker, limestone, and gypsum

Parameter	Material size (mm)		
	Clinker	Limestone	Gypsum
Mode	8	< 1	< 1
Median	7.93	2.88	0.89
Mean	12.01	5.21	8.35

In contrast, limestone exhibits smaller particle sizes than clinker, with a mode of <1 mm, a median of 2.88 mm, and a mean of 5.21 mm. This finer size distribution suggests that limestone is easier to grind compared to clinker.

Meanwhile, gypsum has a particle size distribution dominated by fine particles, with a mode of <1 mm, a median of 0.89 mm, and a mean of 8.35 mm. The smaller particle size of gypsum indicates that this material will undergo comminution more rapidly than both clinker and limestone.

These differences in particle size significantly impact grinding efficiency in the roller press. Coarser clinker requires higher grinding energy, while finer limestone and gypsum can accelerate the grinding process and enhance comminution efficiency. Therefore, maintaining a balanced particle size distribution in the feed materials is essential to ensure energy efficiency and the quality of the final product in cement production.

Overall, the PSD analysis of sample 1 indicates a well-graded distribution, characterized by a relatively wide range of sizes and a balanced proportion of fine, medium, and coarse particles. The average particle size falls within the medium range. In contrast, sample 2 exhibits suboptimal particle size grading. Although the particle size range is relatively wide, the average particle size is coarser and lacks balance with the fine and medium-sized fractions.

### 3.2 Effect of PSD

#### 3.2.1 Effect of PSD on roller press operating parameters

The operating settings of a high-pressure roller press (HPGR), including the working gap, hydraulic cylinder pressure and grinding pressure, depend strongly on the feed's PSD. Coarser feed material produces a thicker particle bed between the rolls, necessitating a wider roll gap and higher applied force to maintain throughput [20].

As shown in Table 3, sample 2, which had a coarser feed ( $F_{80} \approx 20.8$  mm), operated at a larger working gap of 29.92 mm, hydraulic pressure of 123.7 bar, and grinding pressure of 241.4 MPa. In contrast, sample 1, with a finer and more homogeneous feed ( $F_{80} \approx 13.0$  mm), maintained a smaller gap of 27.20 mm and lower pressures (115.3 bar and 236.2 MPa, respectively). These data indicate that coarser feed material increases the resistance against the rolls, prompting a wider working gap and higher hydraulic/grinding pressures. Conversely, finer feed supports denser particle packing in the gap, which leads to smoother compression and reduced pressure requirements. This behavior is consistent with studies of HPGR operation showing that feed size and bed-packing significantly influence roll gap and pressure settings [20].

Mechanistically, larger particles provide fewer fines to fill interstitial voids, resulting in a less-densely packed bed that requires higher compressive force to achieve equivalent throughput. In contrast, feeds containing a greater proportion of finer particles enable tighter packing, enhanced particle-to-particle contact and more efficient stress transfer through the material bed. Accordingly, as confirmed by the data in Table 3, the roller press regulates its operating parameters, increasing hydraulic and grinding pressures when processing coarser feeds and reducing them for finer feeds to ensure steady comminution efficiency. At Finish Mill 8B, the roller press is operated at a grinding pressure typically controlled in the 240–250 MPa range, consistent with the operational values observed. This behavior aligns with recent investigations into HPGR bed-compression mechanics [20].

Table 3. Roller press operating parameters for sample 1 and sample 2

Sample	Working gap (mm)	Hydraulic pressure (bar)	Grinding pressure (MPa)
1	27.20	115.3	236.2
2	29.92	123.7	241.4

#### 3.2.2 Effect of PSD on reduction ratio

The reduction ratio is a suitable metric for evaluating how effectively a comminution machine can reduce the size of the feed material into the desired product size. The results of the PSD test for the product from sample 1 and sample 2 are shown in Fig. 5.

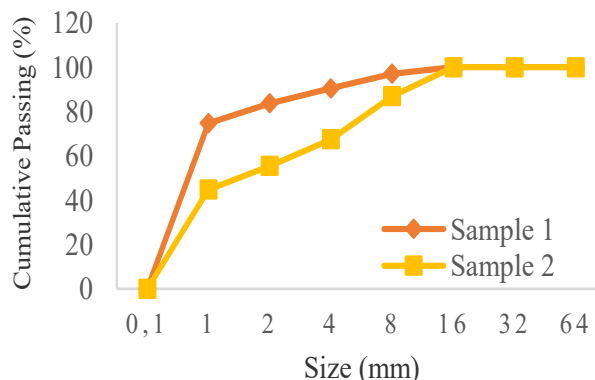


Fig. 5 PSD analysis diagram of product.

From Fig. 5, the trend line of sample 1's product is steeper than that of sample 2. This is due to sample 1 containing a higher frequency of fine particles below 1 mm compared to sample 2.

Table 4. Statistical parameters of product PSD

Parameter (mm)	Sample 1	Sample 2
Mode	< 1	< 1
Median (D30)	0.70	1.49
Mean	1.50	3.48

Additionally, based on the median and mean values in Table 4, the product from sample 1 has smaller particle sizes (0.70 mm and 1.50 mm) compared to sample 2, indicating that sample 1's product is dominated by finer particles.

The reduction ratio of the roller press in this study was calculated based on Bond's Comminution Theory. According to Table 5, the reduction ratio of the roller press when grinding sample 1 material is significantly higher compared to when grinding sample 2 material. The roller press was able to reduce the feed material size of sample 1 to a size 8 times smaller than its original size.

Table 5. Particle size reduction ratio on the roller press

Index	Sample 1	Sample 2
F80 (mm)	12.98	20.76
P80 (mm)	1.59	6.57
n	8.16	3.16

This indicates that the grinding process of sample 1 feed material using the roller press is more effective, as the particle size distribution is more uniform (not skewed toward coarser or finer particles), and the average particle size is in the medium range. As a result, it is easier to produce a finer product compared to that of sample 2.

#### 3.2.3 Effect of PSD on grinding efficiency

The interrelation between raw materials, processes, and resulting products means that PSD also significantly affects the grinding performance. Table 6 shows that differences in PSD among samples result in varying grinding forces and power requirements. For sample 1 feed material, the specific grinding

force required to produce 1 mm<sup>2</sup> of product is only 5.33 N, and the specific power required to produce 1 ton of product is only 6.92 kWh, indicating that sample 1 is easier to grind compared to sample 2.

Table 6. Milling parameters and energy consumption on the roller press

Index	Sample 1	Sample 2
Spec. grinding force, $F_{spec}$ (N/mm <sup>2</sup> )	5.33	5.71
Specific power consumption, $E_c$ (kWh/t)	6.92	8.20
Fresh feed, tph	211.00	189.75
Tailing, tph	359.5	389

In terms of production capacity, the automated feeding system of the roller press significantly influences the PSD of the material feeder, thereby affecting the amount of tailing, which directly impacts the fresh feed rate. As shown in Table 6, the tailing from sample 2 reached 389 tph, resulting in a smaller fresh feed rate of only 189.75 tph compared to sample 1.

Consequently, based on the principle of mass balance, a smaller amount of feed (excluding circulating load) entering the system will yield a reduced quantity of product.

### 3.3 Influence of feed material characteristics based on clinker chemical properties on grind-ability and comminution efficiency

The clinker quality at plant 7 and plant 8 is based on several chemical parameters, namely a minimum C<sub>3</sub>S content of 61% and a free lime content of 0.4-1.4% for plant 7 and 0.8-1.8% for plant 8. These parameters are controlled not only for process control in the kiln system but also for process control at the finish mill, regarding the grinding energy requirements.

In this study, the clinker samples used came from two different production sites, the kilns at plant 7 (P7) and plant 8 (P8). Naturally, the clinker quality and its impact on the grinding process on the roller press also differ.

Table 7 demonstrates that clinker P8, with a C<sub>3</sub>S content of 62.53% and free lime of 1.25%, falls within the quality standard of 0.8-1.8 and exhibits a lower BWI value compared to clinker P7. This suggests that the clinker produced by plant 8 has superior grind-ability, requiring only 12.90 kWh of grinding energy to produce 1 ton of product. In contrast, clinker from plant 7 has a higher BWI value due to its C<sub>3</sub>S content being below the minimum quality standard of 61% and a free lime content of 0.4%, which is within the specified minimum limit.

Table 7. Chemical composition and bond work index of clinker P7 and P8

Chemical composition	Clinker	
	P8	P7
F.CaO	1.25	0.40
C <sub>3</sub> S (%)	62.53	60.68
Bond work index (kWh/t)	12.90	13.97

These findings indicate that clinker with a C<sub>3</sub>S content exceeding the minimum limit and free lime within the acceptable range demonstrates better grind-ability and, consequently, lower energy requirements. Conversely, clinker with lower C<sub>3</sub>S content and free lime exceeding the specified limits necessitates greater energy consumption. This relationship underscores the importance of considering both parameters when assessing clinker grind-ability. Table 8 provides data on the energy requirements of the roller press circuit, calculated using Bond's Law.

Table 8 summarizes the relationship between feed characteristics, energy consumption, and comminution efficiency during roller-press operation. The results demonstrate a clear cause-and-effect relationship between feed parameters and grinding performance. The finer and more uniform particle size distribution (sample 1;  $F_{80} = 12.98$  mm) produced a significantly higher

reduction ratio ( $n \approx 8.16$ ) than the coarser feed (sample 2;  $n \approx 3.16$ ), indicating more efficient size reduction per unit mass. This improved breakage efficiency corresponded to a lower specific energy consumption, with actual power requirements of 6.92 kWh/t for sample 1 compared to 8.20 kWh/t for sample 2—representing approximately a 16% energy saving. Consistently, comminution efficiency (actual vs. theoretical energy) increased from 11.40% to 12.50% for the finer feed, confirming that an improved PSD enhances both the reduction ratio and energy utilization.

Table 8. Comparison of energy requirements and comminution efficiency on the roller press

Parameter	Sample	
	1	2
Feed $f_{80}$ (mm)	12.98	20.76
Product $p_{80}$ (mm)	1.59	6.57
Bond work index (kWh/t)	12.90	13.97
Theoretical energy requirement (kWh/t)	86.41	93.56
Actual energy input (kWh/t)	6.92	8.20
Comminution efficiency (%)	12.50	11.40

In addition to particle-size effects, clinker chemistry also contributed to the observed performance differences. The plant 8 clinker (sample 1), characterized by higher C<sub>3</sub>S content (62.53%) and moderately higher free CaO (1.25%), exhibited a lower BWI = 12.90 kWh/t than the plant 7 clinker (C<sub>3</sub>S = 60.68%, free CaO = 0.40%, BWI = 13.97 kWh/t). This confirms that higher alite (C<sub>3</sub>S) promotes easier grind-ability and reduced energy demand, while moderate free CaO values assist micro-crack formation during cooling, further facilitating comminution. Consequently, the roller press achieved the desired fineness with a lower specific grinding force (5.33 N/mm<sup>2</sup> vs. 5.71 N/mm<sup>2</sup>), demonstrating that optimized feed characteristics—both physical (PSD) and chemical (C<sub>3</sub>S/free CaO)—directly translate into reduced energy consumption and enhanced process efficiency.

These findings agree with established studies reporting that finer feed distributions and higher C<sub>3</sub>S contents enhance clinker breakage and lower specific energy demand [20][1].

## 4 Conclusions

In conclusion, the PSD of the feed material significantly influences the operating parameters of the roller press, the working gap, hydraulic pressure, and grinding pressure. The size of the particle size will exert different resistance forces on the roller. This also affects power consumption and grinding outcomes. Feed material with a uniform PSD and an  $f_{80}$  of 12.98 mm is easier to grind, resulting in a specific grinding force and specific power consumption of only 5.33 N/mm<sup>2</sup> and 6.92 kWh/t, respectively. However, it can produce a reduction ratio of 8.16. This increases production capacity and indicates a more effective grinding process.

The chemical composition of the clinker significantly influences the grind-ability, energy, and comminution efficiency of the roller press. This is evident from the fact that a higher C<sub>3</sub>S content and an acceptable free lime level make the clinker easier to grind, resulting in lower power requirements and increased comminution efficiency in the roller press. It is known that clinker with a C<sub>3</sub>S content of 62.53% and free lime of 1.25 exhibits good grind-ability with a WI value of 12.90 kWh/t so that the efficiency of the roller press can reach 12.50%.

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