SEPARATE OR INTERGRINDING?

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Apart from the typical list of advantages and disadvantages related to both separate grinding and intergrinding, cement performance was the focal point of a more detailed study by Cementir for its Taranto plant. The cement producer wanted to determine the possibility of producing CEM III/A that could develop an early (two-day) strength of 25MPa. The main objective was to produce a slag cement (CEM III/A) with similar properties to those of a CEM II/A (LL), the most common cement type consumed on the local market. Early strength and the avoidance of performance enhancing additives were key factors for consideration.

**Separate grinding vs intergrinding**

Looking specifically at the pros and cons of separate grinding compared to intergrinding, which is the focus of this article, a detailed test programme was set up for the Taranto works which can be used by other cement companies faced with the same dilemma.

The selected equipment supplier, Loesche, allowed for an elaborate test programme to be undertaken using its small test mill with clinker and slag sourced from the Taranto works. The ground samples were then shipped to Cementir’s R&D laboratory in Aalborg, Denmark, for further analysis.

In preparation for a major project at Cementir’s Taranto cement plant in southern Italy, the dilemma of whether to arrange the two new vertical mills for separate grinding or intergrinding arose. With the help of milling specialists Loesche, an extensive test programme was carried out to find the best option in terms of cement performance, flexibility and cost effectiveness.
sulphate optimisation, chemical analysis and strength (mortar) testing.

Due to an unforeseen influence from prehydration on the interground samples during the mill feed, the test had to be repeated. However, this turned out to be an important part of the learning curve because it brought to the forefront the key point of how to arrange the feed system on a full-scale mill and the prominent role moisture plays.

During the first trial, slag samples taken after the drier were shipped, but no moistening took place for the subsequent intergrinding test, so the power draw on the mill during separate grinding was higher than expected. This helped understand the role of moisture in slag grinding later on.

The test series were designed to get the best coverage of the CEM III/A composition that spans from 35-65 per cent granulated blast furnace slag (GBFS) and two test runs were made with 40 and 60 per cent, respectively. For both levels of GBFS, grinding tests were conducted at various comparable finenesses (see Table 1). For strength measurements sulphate optimisation was made prior to casting standardised mortar prisms according to EN 196-1.

Findings
Moisture normally associated with GBFS is an important parameter because water acts as a grinding aid and helps stabilise the grinding bed in the mill. However, it also presents the risk of pre-hydration. This is where the use of vertical mills for slag grinding offers a further benefit as the mill not only grinds the material but also dries it in the process. The normally-moist slag, with an eight per cent water content, is dried and ground in one step while the water helps to stabilise the mill operation during grinding. This also lowers vibration and specific power consumption on the main drive (see Figure 1).

Specific power consumption can be also reduced by using wet slag in an intergrinding process. A material containing 40 per cent slag with a moisture content of 3.2 per cent shows power consumption during intergrinding comparable to power use during separate grinding (see Figure 2).

However, the combination of cement fineness and slag fineness in interground cement may not be the optimum to provide the maximum strength for a given Blaine. Separate grinding offers the option whereby the fineness ratio of the components can be optimised, eg through kriging (Stein, 1999).

Therefore, blended cements from separately-ground products mostly show higher-strength data compared to interground mixtures. Interground CEM III/A providing 2d>25MPa must be ground more finely than separately-ground counterparts to achieve the same strength performance (see Figures 3 and 4).

For the 60 per cent GBFS these results were less conclusive because none of the test runs were conducted at sufficiently-

<table>
<thead>
<tr>
<th>Material</th>
<th>Wet slag (%)</th>
<th>Clinker (%)</th>
<th>Gypsum (%)</th>
<th>Limestone (%)</th>
<th>Blaine fineness (m²/kg)</th>
<th>Specific mechanical power consumption (kWh/t)</th>
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<tbody>
<tr>
<td>Separately-ground wet slag</td>
<td>100</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>348</td>
<td>16.7</td>
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<td></td>
<td></td>
<td>368</td>
<td>387</td>
<td>435</td>
<td>528</td>
<td>28.7</td>
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<td></td>
<td></td>
<td>572</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Interground cement with</td>
<td>61.54</td>
<td>34.42</td>
<td>1.15</td>
<td>2.82</td>
<td>360</td>
<td>18.2</td>
</tr>
<tr>
<td>60 per cent of wet slag</td>
<td></td>
<td>382</td>
<td>410</td>
<td>458</td>
<td>527</td>
<td>19.5</td>
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<td></td>
<td>28.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Interground cement with</td>
<td>41.56</td>
<td>53.42</td>
<td>2.1</td>
<td>2.92</td>
<td>334</td>
<td>17.0</td>
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<tr>
<td>40 per cent of wet slag</td>
<td></td>
<td>372</td>
<td>432</td>
<td>448</td>
<td>463</td>
<td>20.1</td>
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<td>22.5</td>
<td>25.7</td>
<td>26.6</td>
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<td>Separately-ground cement</td>
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<td>3.6</td>
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<td>316</td>
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<td>539</td>
<td>34.8</td>
</tr>
</tbody>
</table>

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high Blaine values to achieve the desired results.

Furthermore, it is well known that the vent air requirement when grinding slag separately is around 15 per cent less than when grinding clinker or clinker and slag together, because the mill has to be set up for the lowest common denominator (which is clinker when it comes to early strength).

Separate grinding typically requires two mills, or if one bigger vertical mill is chosen, a complicated programme has to be developed where the mill is not truly optimised for either of the conditions despite flexibility when switching between product qualities.

In the case of the Taranto project, two new vertical mills were planned from the outset, but other options would have been possible. For example, clinker could be ground in an existing ball mill and GBFS in a single vertical mill because the advantages are relatively higher for slag grinding than that of clinker grinding.

While the use of two vertical mills would improve grinding economy, it is often difficult to justify capital investment in a new vertical clinker grinding mill based on power savings alone.

However, separate grinding requires thorough mixing and proportioning of the ground slag and cement. Typically that is best carried out on a pug mill or a similar device. Mixing in air slides and/or bucket elevators may suffice, but to ensure the best result, a dedicated mixer is recommended. While separate grinding requires slightly more equipment, it provides a higher level of sub-optimisation of the product performance to a specific target. The issue of sub-optimisation is also very site specific because there are areas where that process historically can only take place at the ready-mix, block or pre-cast plant, but a cement plant is always better equipped for fine-tuning.

Intergrinding offers the advantage of simplicity, both in terms of layout and operation. It is regarded a more straightforward option for operators because the mills are identical and the impact of proportioning is less pronounced. As part of the system layout, it is important to ensure that the clinker and wet slag are kept separate for as long as possible. However, having two material inlets to the mill is not required as this has drawbacks in terms of false air and maintenance.

The separate selection

The test results showed that to achieve high early strength on slag cement using Taranto’s GBFS, separate slag and clinker grinding is a more efficient process than intergrinding. It also proved to be the more flexible and economical method because the mills can be optimised for the products they are producing. The option of blending one class of slag cement with different amounts of slag and of varying fineness allows for the production of special qualities to satisfy different customer requirements.

While a viable option, intergrinding often provides a slightly simpler set-up, but in the long term the operational cost will exceed that of separate grinding.

References

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Loesche is an export-oriented company run by the owner, which was established in 1906 in Berlin. Today the company is internationally active with subsidiaries, representatives and agencies worldwide.
Our engineers are constantly developing new ideas and individual concepts for grinding technologies and preparation processes for the benefit of our customers. Their competence is mainly due to our worldwide information management. This ensures that current knowledge and developments can also be used immediately for our own projects.
The services of our subsidiaries and agencies are of key importance for analysis, processing and solving specific project problems for our customers.

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