Finish grinding by Roller Press

Roller Press technology has long since proven its ability to grind raw materials and slag in a cost-effective way. However, the technology is increasingly making its mark with cement producers for the finish grinding of cement.

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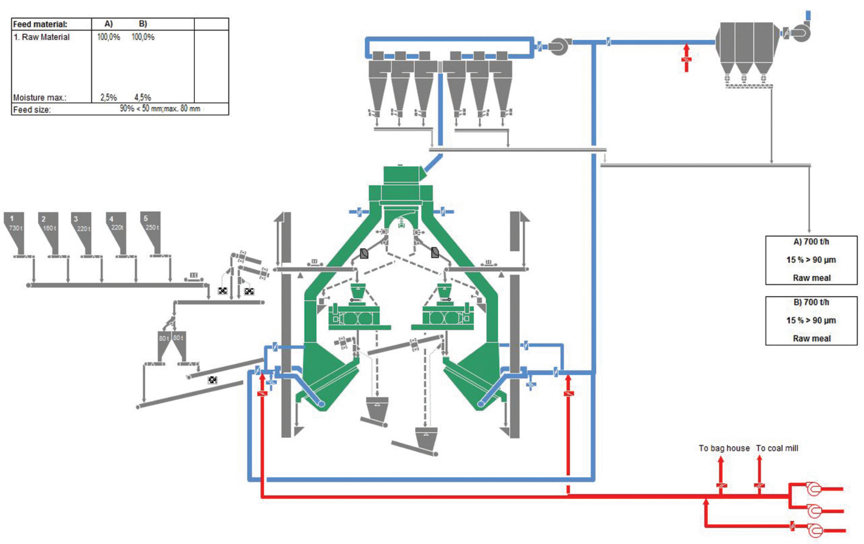
In 1977 a revolutionary idea of a different grinding technology was born. Prof Klaus Schoenert invented and patented this grinding technology with the title "Method of fine and very fine comminution of materials having brittle behavior". In the 1980s KHD Humboldt Wedag picked up this idea and pioneered its application with the first industrial Roller Press (RP) for the pregrinding of granulated blast furnace slag. In combination with the invention of the static V-separator a few years later, the company cleared the way for the worldwide expansion of RP technology as a grinding unit.

Figure 1: process flow sheet of the COMFLEX®-D raw material grinding circuit



Raw material and slag grinding

In the beginning the RP was used only in combined mode with either a ball mill or even with impact hammer mills. The first raw material grinding circuit in finish mode based on RPs was installed in the 1990s, and since then, this configuration has become the state-of-the-art technology for raw material grinding.

Today several dozens of RP in finish mode are installed worldwide. The biggest grinding circuit was commissioned in 2016 in India with a capacity of 700tph. This grinding unit is part of a "COMFLEX®-D" arrangement, which includes two of KHD's largest RPs (ϕ2.2m x 1.8m width). The system also includes one of KHD's largest dynamic separators, SEPMASTER SKS-V 5000, which has a cage wheel diameter of 5m. The process flow sheet of the circuit is shown in Figure 1.

A summary of plant performance and operational data as represented by performance guarantee (PG) test results can be seen in Table 1.

However, the main focus of RP development from the beginning was the grinding of slag. The first slag grinding circuit in finish mode was installed in the mid-1990s and currently, there are more than 20 RP circuits in finish mode in operation to grind slag.

Table 1: summary of PG test results of raw material grinding plant

Parameter	Performance guarantee	Achieved values (as per PG test)
Raw meal production (tph)	700	730
Product fineness (%R on 90µm)	15	15.98
Specific power consumption – at meters for equipment within battery limits (kWh/t raw meal)	17.5	18.4

Table 2: summary of PG test results of slag grinding unit at JSW Cement's Nandyal plant, India

Parameter	Performance guarantee	Achieved values (as per PG test)
Raw meal production (tph)	170	194
Product fineness (cm^2/gm)	4500	4560
Specific power consumption – at meters for RP, separator and separator fan (kWh/t raw meal)	35.8	34.86

Slag grinding at JSW Cement, India

One example of an application using the RP for slag grinding are the two slag grinding units of JSW Cement in India. The contract for two slag grinding plants designed for 170tph slag meal each was revived in 2010 by JSW Cement, India, for its Nandyal plant. Each grinding circuit consists of two RPs (RPS 16-170/180, ϕ1.7m x 1.8m width) and two V-separators. Figure 2 shows the process flow sheet of Slag Mill No 2 with two dynamic separators.

Figure 2: process flow sheet of slag mill

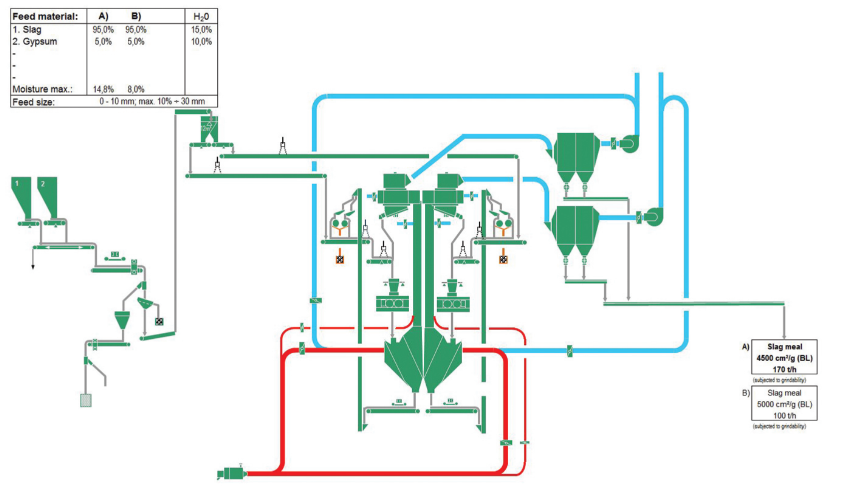


Figure 3: process flow sheet of cement mill

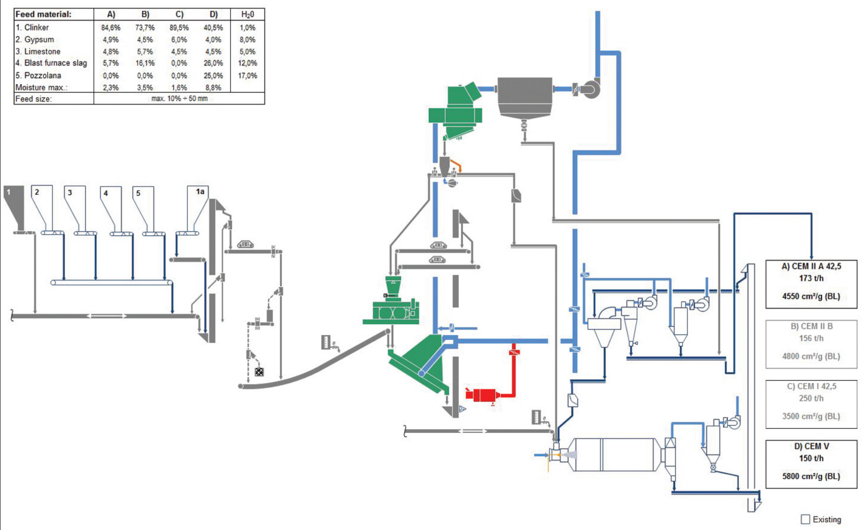
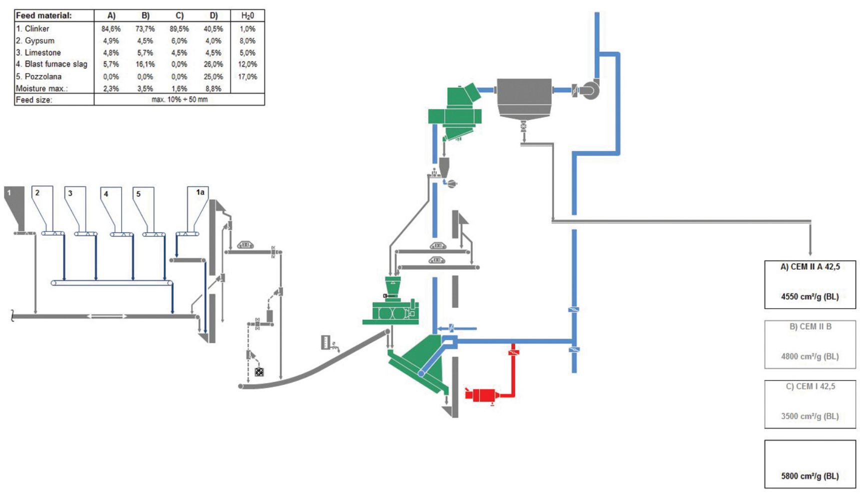


Figure 4: process flow sheet of cement mill in RP finish mode



The operational parameters during the performance test are shown in Table 2. Due to the outstanding results JSW Cement has ordered 16 more COMFLEX systems for slag grinding.

Cement grinding

Grinding of cement with RPs in finish mode has not yet seen a significant uptake and cement producers remain somewhat reluctant to use RPs in this set-up.

Figure 3 shows the flow sheet of an upgrade project in Turkey, where KHD Humboldt Wedag has more than doubled the capacity of a ϕ4.4m ball mill with the installation of a COMFLEX system. The raw material is fed to the COMFLEX system, and is dried and ground to the desired product fineness. The rejects of the dynamic SKS separator are divided into two streams. One part of the rejects is fed to the RP and the other is fed to the existing ball mill system. The product from the new installed COMFLEX system and the existing ball mill grinding circuit is mixed and sent to the cement silo.

A unique feature of this grinding unit is the ability to process feed material with a high (up to nine per cent in that case) moisture content. With the installation of a static V-separator the processing of very high moisture feed can be handled in continuous operation without any issues, since the V-separator was designed not only for the deagglomeration of slabs from the RP and preseparation but also for the drying of moist material. COMFLEX systems have been in operation for many years in cases where the moisture of the fresh feed exceeds 14 per cent.

Through the introduction of such upgrades, cement producers are able to operate the COMFLEX system in finish mode (see Figure 4).

Together with its client, KHD Humboldt Wedag has conducted several tests to compare the cement quality ground in the RP and ball mill together (RP+BM) as well as in the RP only. During one of the tests two different cement types were ground

Table 3: composition of CEM II and CEM IV cements

Parameter	CEM II	CEM V
Clinker (%)	84.6	40.5
Gypsum	4.9	4
Limestone	4.8	4.5
Slag	5.7	25
Trass	0	26

Figure 5: PSD of CEM II A-M (S-L) 42.5 R

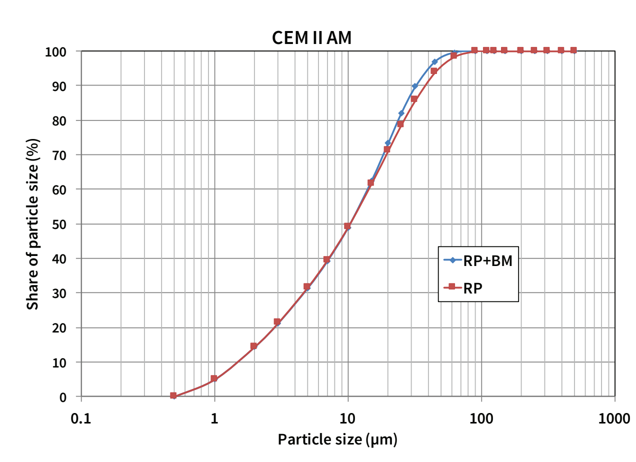


Figure 6: PSD of CEM V A (SP) 32.5

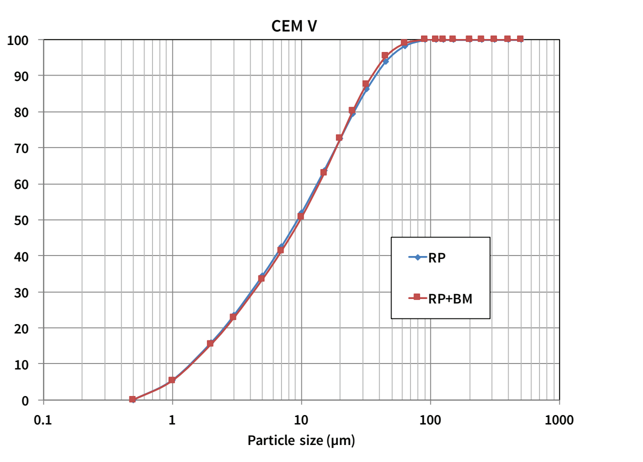


Table 4: cement properties of CEM II and CEM V cements with RP+BM and RP grinding systems

Parameter	Grinding system	Fineness		Water demand (%)	Setting		Strength (MPa)		
		R45µm (%)	Blaine (cm²/g)		Initial (min)	Final (min)	2 days	7 days	28 days
CEM II	RP+BM	1.4	4600	30.0	135	180	37.2	53.4	66.8
CEM II	RP	2.4	4560	29.5	125	165	35.2	51	65.1
CEM V	RP+BM	1.2	5550	35.5	200	270	11.1	19.7	38
CEM V	RP	1.8	5600	35.0	175	210	11.6	20.8	37.6

(see Table 3 for the composition of these cements).

All cement types were analysed in terms of particle size distribution (PSD), fineness, strength development, water demand and setting time. The PSD was measured with a modern Sympatec laser diffraction spectrometer.

The PSDs of the CEM II cement in the RP finish mode and RP+BM mode are shown in Figure 5. Below 20µm no difference can be detected despite the different grinding mechanisms of the BM and RP. Above 20µm the RP+BM mode shows a steeper inclination of the PSD, which is normally unfavourable for the cement properties. The difference based on the cumulative PSD is less than five per cent between 20-50µm. The maximum particle size is comparable for both cements.

The PSDs of CEM V cement show little difference between the cumulative PSDs of both grinding options over all particle sizes (see Figure 6). In the small particle sizes as well as the coarser particle sizes no significant difference can be detected. The composition of the cement seems to be a factor in the created PSD. CEM V cement contains very difficult-to-grind material such as slag as well as materials that are easy to grind, such as trass. Slag that is ground with higher pressures reaches a very fine PSD. In the past tests have been carried out by KHD and other customers that achieved a product fineness of >8000cm^2/g. Therefore, it can be assumed that slag-containing cements obtain a wider PSD range more easily when ground with RP technology.

In terms of compressive strength, water demand and setting time, as well as residues on 45 µm and Blaine no major differences can be detected. The residues on 45 µm show only small differences for both cement types in spite of almost identical Blaine values (see Table 4). Particularly for CEM II this difference cannot be explained with the PSD measured by laser diffraction since it shows fewer residues in the coarser fraction for the RP cement.

However, most important for end-users are characteristics such as water demand, the setting time and especially, the compressive strength of the product. CEM II ground in finish mode with RP technology reaches identical properties to the cement ground in RP+BM. In particular, water demand of the RP finish-mode cement, which is a key factor for concrete producers, shows the same value – in this case, even lower by 0.5 per cent. The setting times differ by just 10 and 15 min, respectively for cements with identical sulphate composition. This small difference can be easily offset by gypsum content and composition. The strength development differs only slightly.

CEM V cements ground in RP finish mode show also similar properties as the cements ground with RP+BM. The water demand is 0.5 per cent lower for the product using RP finish mode compared with that ground by a RP+BM set-up. Strength development is almost identical for both grinding methods. Only the setting time shows differences which can be offset by optimising sulphate content.

Summary

Finish grinding of granulated blast furnace slag and raw materials with a RP exclusively has been a well-proven technology for many years. It is the most economical way to comminute these materials. Particularly in recent years, cement producers have increasingly opted for high-pressure comminution, as offered by RP technology.

The latest project outcomes show that RP technology cannot only be applied to raw material and slag but also to cement grinding in finish mode.

Benchmarking of different cement types ground with a sole RP unit and a COMFLEX RP+BM system provide similar grinding results and cement properties. ■