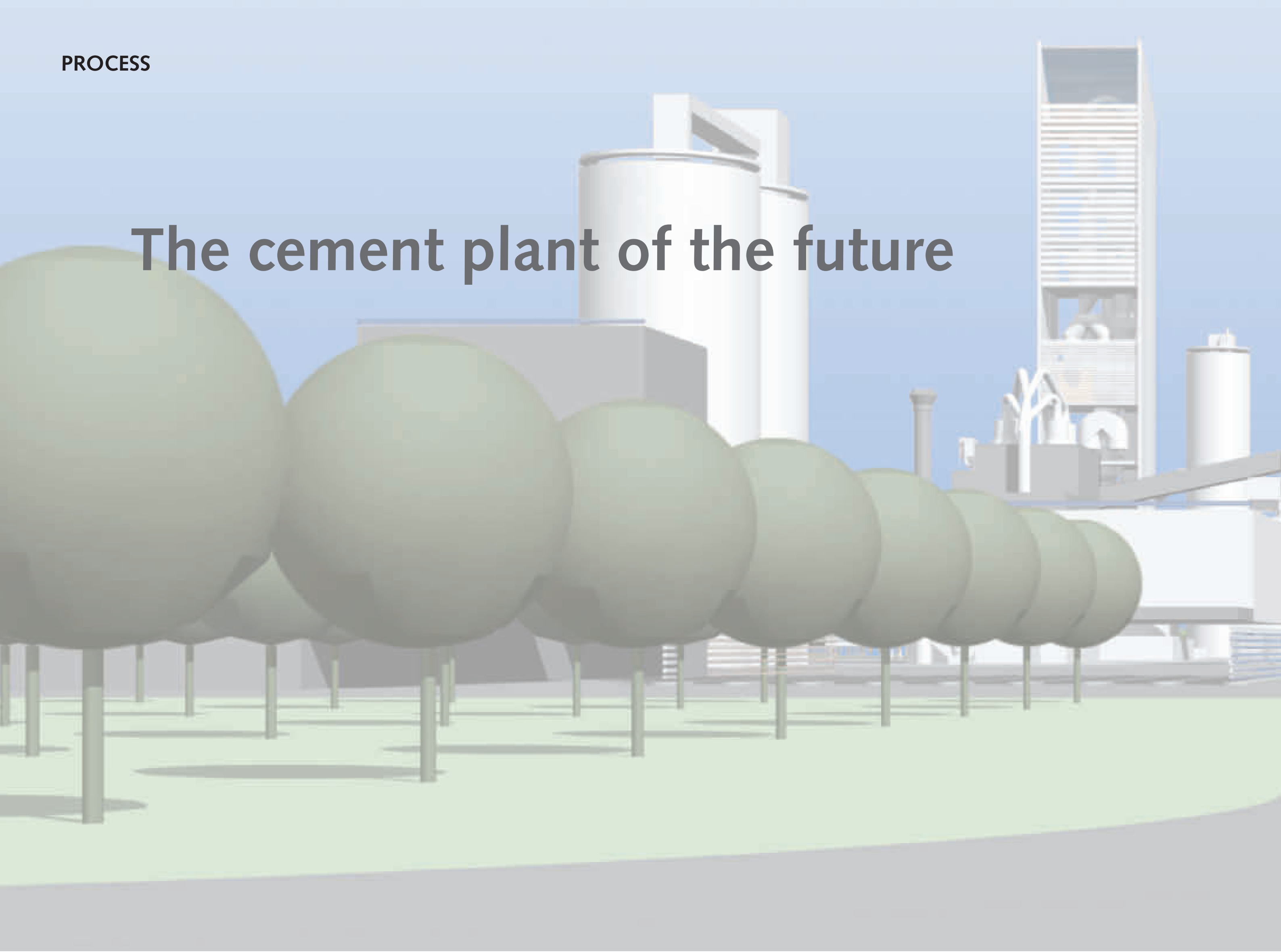

HAVER NIAGARA

Making more products, reducing waste and cutting costs in the quarry

1 Introduction

Haver & Boecker has made up its mind. The company located in Oelde/Germany wants to shape the future of the cement industry. Its objective is to begin designing the cement plant of the future. First stop – Mineral Processing. The basis for quality and cost of the cement starts here. Process-engineering research in the cement industry has always aimed at

- Reducing energy consumption in cement production
- Optimizing quality and uniformity of produced cement, and
- Minimizing emissions from the cement-production process [1, 2]

The starting point for all these goals is naturally the starting point of the complete process. Haver & Boecker as well as its technology brand W.S. Tyler suggest redesigning the limestone quarry with a special focus on:

- Extending the range of sellable product by installing specialized technology in the immediate vicinity of the cement plant
- Improving the efficiency of material extraction from natural deposits

2 Let's review – from limestone to cement

This task necessitates a conversion analysis for the raw materials within the cement-production process, from limestone to cement. As Figure 1 shows, a mixture consisting of limestone (approx. 70 to 80 % by mass) and clay/marl (approx. 20 to 30 % by mass) present in native form in many natural deposits for cement raw materials [2] is the starting point for the production of cement. Depending on

The first part of the Haver & Boecker "The cement plant of the future" series of articles focussed on preparation technologies. The subsequent parts examine groundbreaking solutions for storage and handling, packing, palletising and loading, ship loading, unloading and automation.

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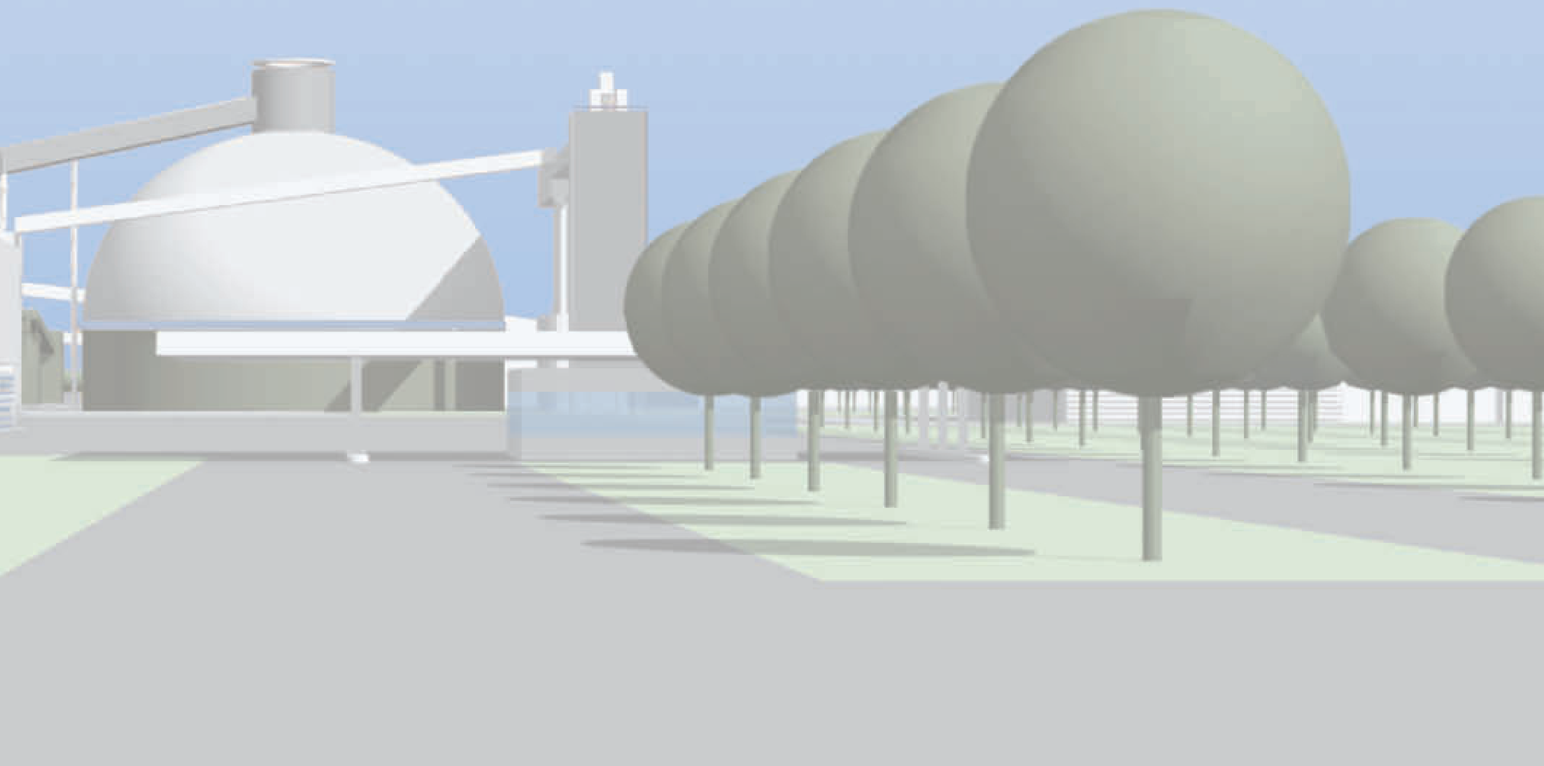

Illustration: Thierry Bogaert*

the chemical composition of the raw material deposit, further components such as iron ore or sand must be added. Following excavation by means of drilling and blasting or heavy equipment, the material is conveyed to the crushing plant where the ROM material is subjected to pre-crushing (using impact or hammer crushers, for example), and is then further homogenized. Grinding to raw meal using vertical roller or ball mills follows in the raw meal plant. The raw meal is then deacidified in the clinker plant by breaking down the $CaCO_3$ limestone into its CaO and CO_2 components. Burning at approx. 1450 °C in the rotary kiln then takes place until sintering occurs. After cooling, the cement clinker is ground in the cement grinding plant while sulphates (e.g. gypsum) are added to yield various grades of fineness (cement qualities). Deliveries of cement take place primarily by means of shipment in silo vehicles or in bags, by water, rail and/or road transportation. The ready-mixed concrete industry (approx. 52 %), and the manufacturers of pre-cast concrete elements (approx. 26 %) are among the main customers for cement. The cement-production process is always dependent on the proximity of a suitable natural raw material deposit.

3 The cement plant of the future makes more products while transforming waste into sellable goods

Limestone sedimentary rock is needed not only for cement production, but is also an important raw material in the building materials, agriculture, water management, steel, glass, fertilizers and paper industries. Stone products are currently produced at and shipped from self-contained facilities (e.g. pre-crushing and gravel plants) in the vicinity of the natural deposits [3]. The concept of additionally using the cement plants' material deposits more intensively is therefore an obvious step in improving the efficiency of natural deposit exploitation. The cement

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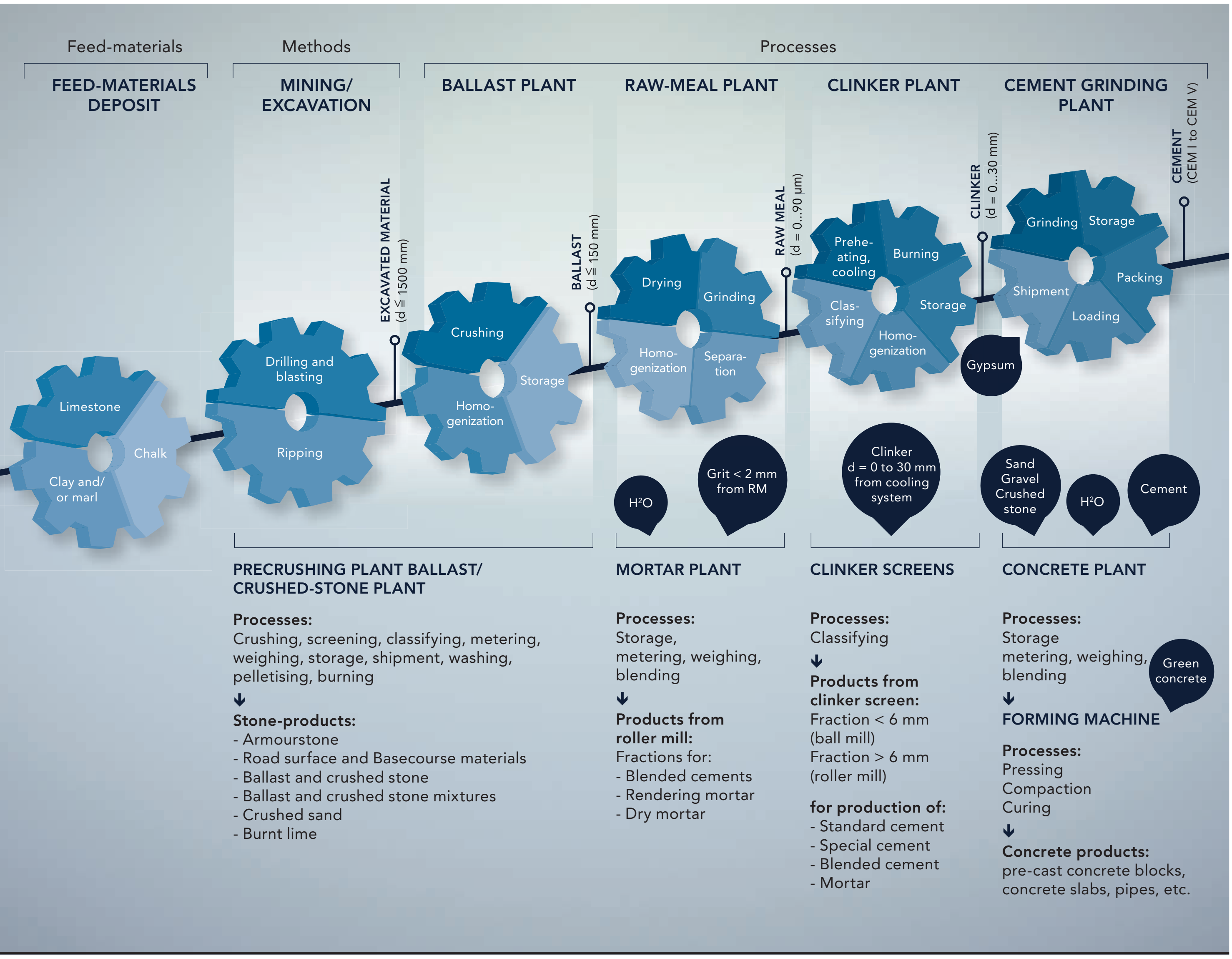
Bogaert' Architecture, based in Paris/France, advocates a global approach encompassing landscaping, urban planning and architecture. Besides the traditional fields of architecture such as housing, offices, and equipment, Thierry Bogaert, the creator of the illustration, focuses on industrial architecture like the integration of industrial facilities into their natural, urban, and port environments. His architectural office has developed about sixty major schemes in about twenty countries so far, in particular for the cement industry. Bogaert regularly presents his method of analysis and of action at cement industry conferences.



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1 Greatly simplified diagram of cement production, showing innovation clusters

plant of the future focuses on making use of existing overcapacities in the cement plants' material deposits, and transforming frequently encountered deposit types which are not suitable for cement production to sellable products by removing impurities. In both cases after the primary and/or secondary crushing stages, a portion of the mineral can be used for producing various stone products such as crushed stone and/or gravel (see Figure 1, Cluster I).

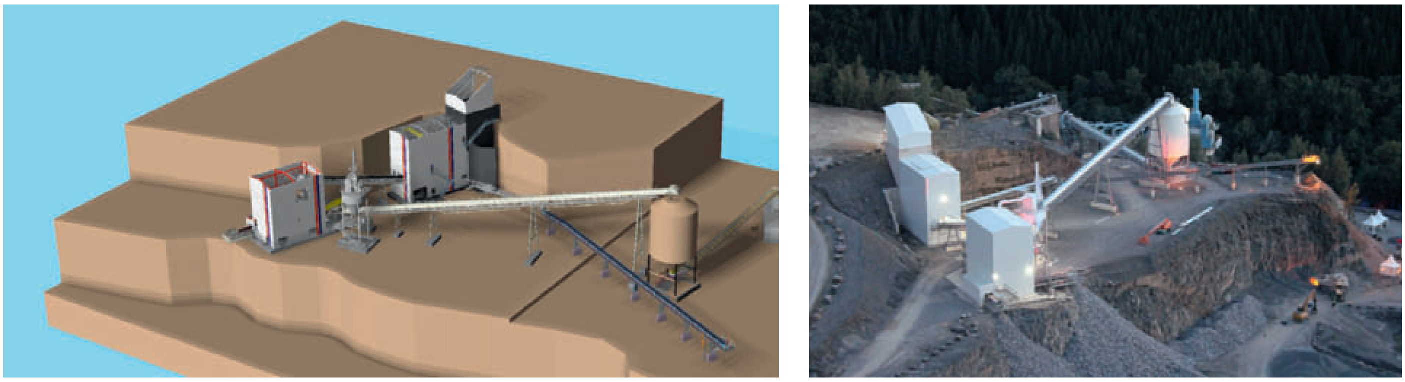
3.1 Adding to the product line – mortars

Even today, most cement producers outside of Europe are not seizing the opportunity of adding mortars to their cement product line. Mortars are relatively simple to make and achieve a significantly higher price per ton compared to pure cement. The cement plant of the future is equipped to optimally process limestone for the correct mortar additives. Limestone grit, e.g. of the 0.1/1.2 mm

Tab. 1 Competence matrix of Haver Niagara GmbH Münster [8]

Materials groups/Industries	Main and subsidiary processes			Engineering services		
	Screening	Washing	Agglomeration	Conveying	Plant engineering*	Engineering ** Service ***
Mining	X	X	X	X	X	X
Cement	X	X	X	X	X	X
Building materials and minerals	X	X	X	X	X	X
Chemicals (fertiliser industry)	X	X	X	X	X	X
Foodstuffs and animal feeds	X		X	X		

Key:
* Crushing and classifying, washing, pelletizing systems
** Feasibility studies
*** Spare parts service, training courses, inspection and maintenance service, plant/system optimization, washing and screening tests, wear-protection



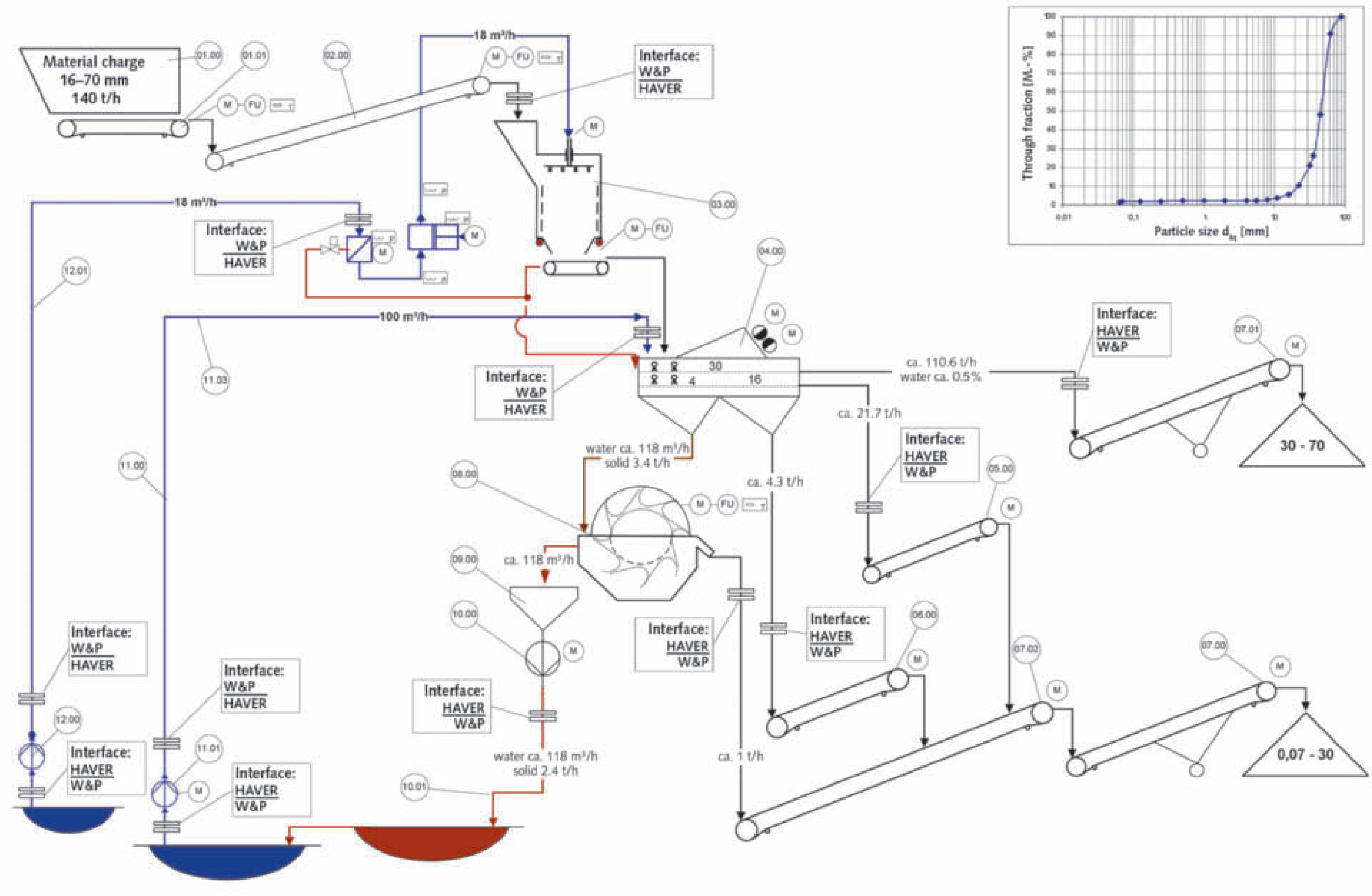
2 Structure of the overall plant, showing integrated armourstone production at the Kleinhammer greywacke quarry
left: 3D view of project
right: Implementation at the Kleinhammer greywacke quarry

fractions, is an optimum raw material for further processing into typical fine-sand fractions that are needed for the production of blended cement or of rendering and dry mortar. Figure 6 shows a system diagram. Downstream from the raw-meal mill the limestone grit is sifted (removal of the ultra-fine particulates fraction <0.09 mm from the material flow) in a classifier and then is fed to the mechanical fines screens for separation into fractions. Fractions of d < 2 mm can be used as dry mortar, cement additives, and for flue-gas desulphurization. It has become apparent in practical application that the use of the Fine-Line Screening Technology (see Figure 7) makes it possible to produce limestone grit for dry mortar production at high throughput rates and with precise cut sizes (also see Figure 1, Cluster II).

3.2 Adding to the product line – burnt-lime production

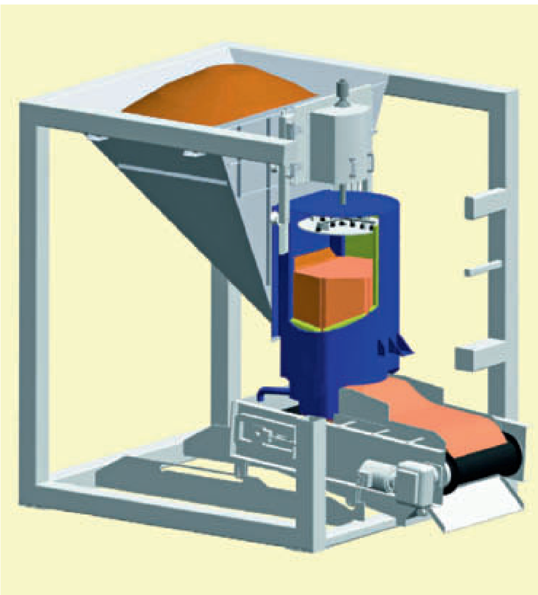
An additional application for limestone is the production of burnt lime. Burnt lime (CaO) is a powder produced by burning limestone at approx. 800 °C. Burnt lime reacts with heat to form slaked lime ($Ca(OH)_2$) when water is added. Burnt and slaked lime are used by a broad range of industries. For example it is used as an additive for the production of mortar in the construction industry, as agricultural lime in the fertilizer industry, and for desulphurization of “hot metal” (unrefined iron from the

3 Niagara DS 1600 x 5000 eccentric screening machine



4 Flow sheet for the preparation facility at Wietersdorfer & Peggauer Zementwerke GmbH's plant in Peggau

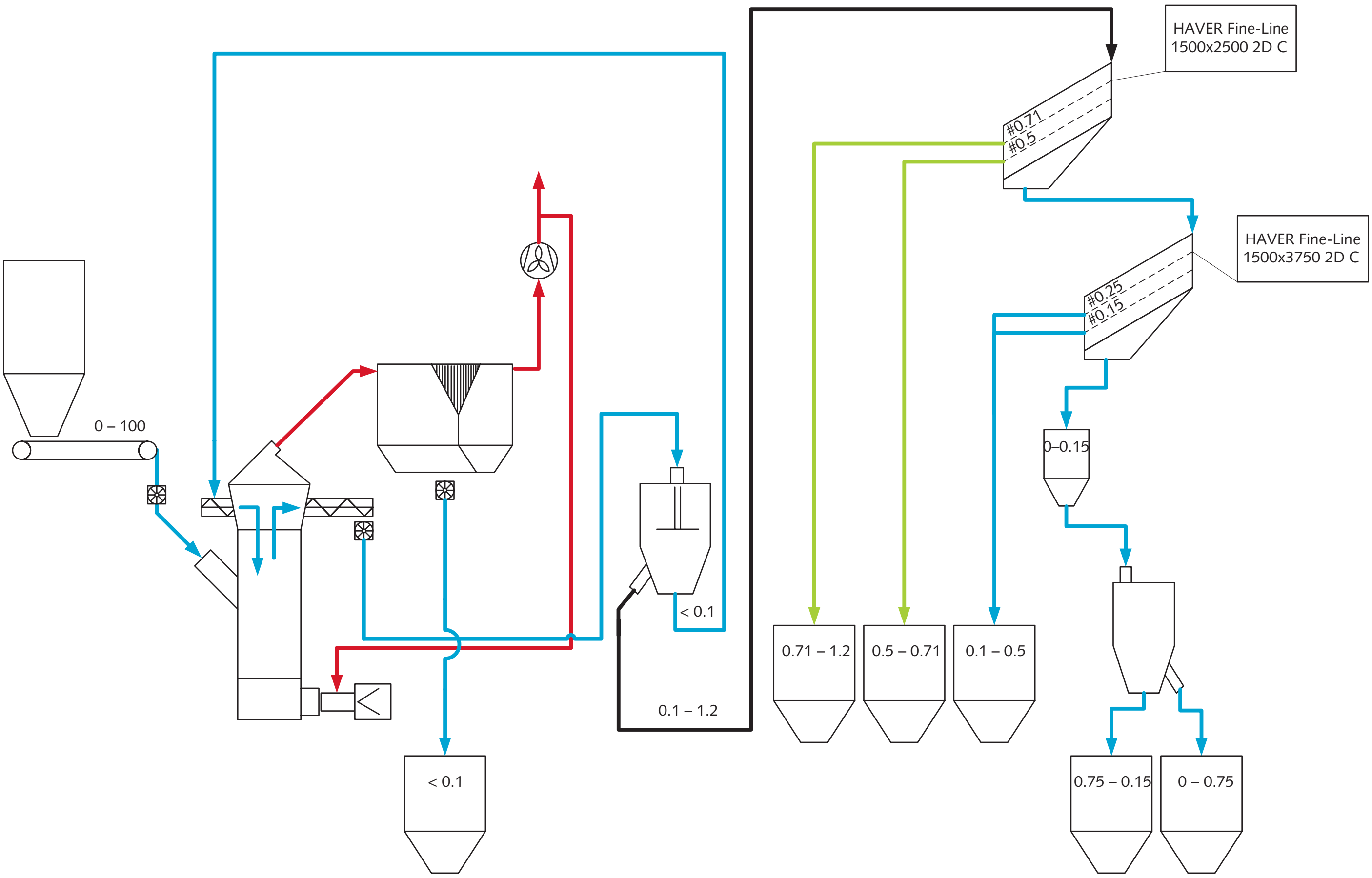
blast furnace) in the steel industry. Slaked lime can also be used as an alternative to limestone in flue-gas desulphurization in power-generating plants [1, 2, 3]. The cement quarry of the future will be outfitted with the required technology to produce burnt lime when and where feasible in order to increase revenues, which will offset the cement production costs.



5 Diagram in principle of the Hydro-Clean

3.3 Transforming waste into sellable products by removing impurities

How can we turn waste into sellable product? The cement quarry of the future answers the question. It utilizes the Hydro-Clean Technology. The Hydro Clean was designed to wash minerals using high-pressure. This combines the highest cleaning power possible with the lowest possible water consumption. The start-up of a low-wear, energy-efficient and resource-conserving high-pressure washing facility for the supply of high-quality limestone fractions for further processing using the Hydro-Clean technology took place at Wietersdorfer & Peggauer Zementwerke GmbH's Peggau plant near the city of Graz/Austria in 2009/10 [7]. Figure 4 shows the flow sheet for the material preparation plant. The high-pressure washer shown in Figure 5 was used for cleaning of the heavily fouled deposit material and achieved extremely good cleaning results with a water consumption of only 1.5 m^3 per metric ton. The material is exposed to cleaning in the washing chamber (4) for approx. 3 seconds. It is then removed from the washing chamber via a frequency-controlled extraction belt (5). The material's exposure period can be modified to match the bonding (e.g. bond form, bond type and bond strength) between the contaminant and the product itself by altering the speed of the extraction belt.



6 System diagram for grit-fraction preparation

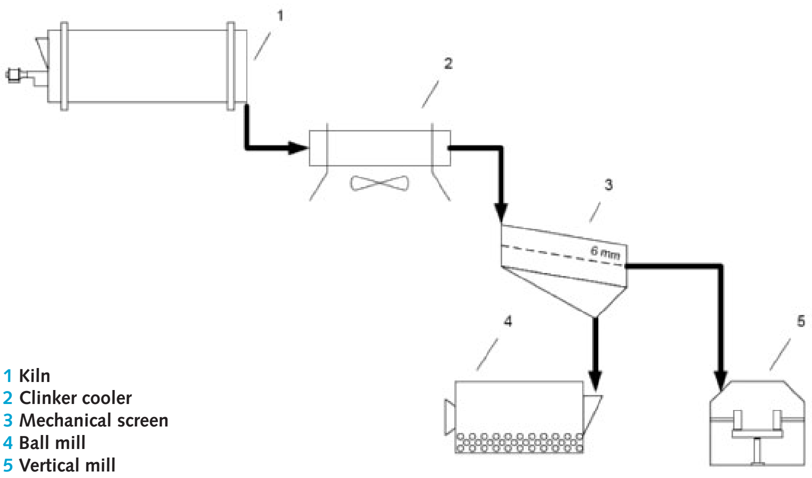
This makes it possible to react flexibly to fluctuations in deposit material, and so ensure constant uniform cleaning for prolonged periods of operation. A wet screen for production of the 0/5, 5/30 and 30/70 fractions was also used in the material preparation plant, in addition to the installed high-pressure washing system. After washing the coarser 30/70 fraction is routed to the burnt-lime kiln while the finer fractions (0/5 and 5/30) are used for producing dry mortar. The resulting washing water is then cleaned by a water-treatment plant and again fed back into the washing process. Loam yielded in this process is routed as a corrective to a clinker production plant.

4 The cement plant of the future reduces costs

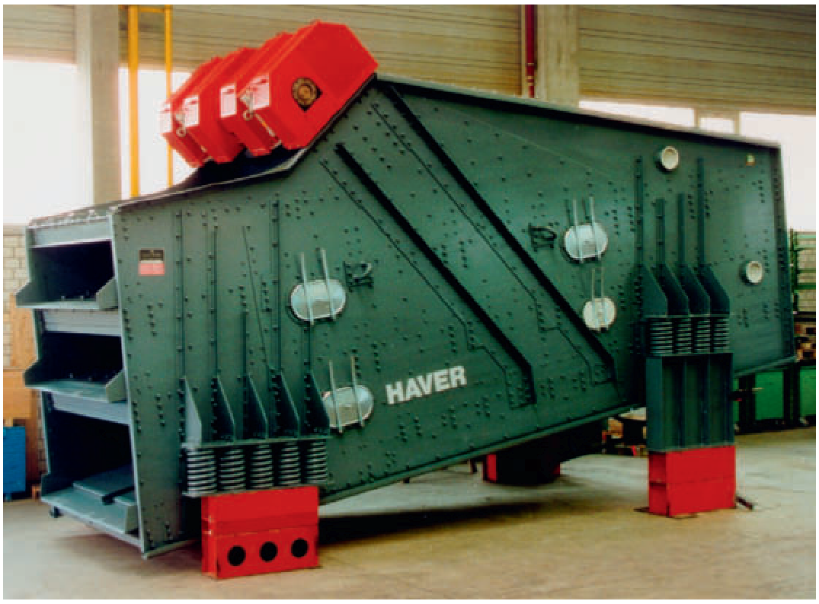
4.1 Saving costs using a Niagara pre-crushing plant

Most limestone quarry world-wide use a grizzly scalping screen. Some do not pre-treat the material prior to entering the primary crusher at all. This results in the unnecessary processing of materials, creates bottle necks within the crusher and jeopardizes the product quality for the subsequent processing steps. Using the Niagara Scalping System, ROM material can be pre-sized prior to entering the crusher, creating a final product at the very first step of the process. The Niagara Scalper utilizes an eccentric shaft supported by a total of four bearings. This technology guarantees a continuous vibration under all operating circumstances. This keeps the screen surface openings clean and guarantees full removal of all fines, which in return allows for reduced crusher wear and in-

7 Haver Fine-Line HD 1850 x 3750 fine-fraction mechanical screens



8 Diagram in principle of clinker screening with downstream separate grinding



9 Haver Niagara clinker screen, with three decks

creased overall system performance. Common grizzly screens offer neither of these advantages. A new pre-crushing plant with an integrated armourstone production facility was engineered and constructed at the Kleinhammer greywacke quarry in Germany's Sauerland region in the 2012/13 period [4]. The scope of supply included not only the Niagara Scalping Screen System and armourstone plant, but also all conveying equipment, temporary-storage and dust silos, structural planning and complete installation. An example of flexible production is provided by the armourstone facility, on which the 4 to 40 kg and 10 to 60 kg weight classes can be produced singly or simultaneously as needed by means of two "Niagara" type heavy-duty mechanical screens (see Figure 3). Due to optimal project planning, implementation time for the complete plant from start to commissioning was only some twelve months. The cement plant of the future includes the Niagara Scalping System-based pre-crushing plant to optimize product quality and operating costs.

4.2 Saving costs by screening clinker downstream

A further example on the road to the cement plant of the future is the screening clinker downstream with separate grinding project. The starting point for these ideas was the generation of clinker fines as a result of the rapid cooling setting properties of the cement. The cooled clinker is then routed via conveying systems to the clinker storage facility. The cooling and conveying process resulting from the system causes a clinker fines fraction < 5 mm of up to 30 %.

4.3 Saving costs grinding clinker

Ball mills have proven their capabilities for clinker grinding for many years. Single-stage grinding using vertical and horizontal mills and high-pressure roller mills have also become popular during recent years. These mills are suitable for the production of standard grades of cement. In granulometric terms, special grades can still be produced to a higher quality by using ball mills. For this and for a number of other market-specific reasons, the cement plant of the future will still contain both alternatives and possible even combination of these mill types. Both ball and vertical roller mills will continue to be state-of-the-art for clinker grinding in upcoming years. Based on an energy analysis, it would therefore appear rational to comminute various clinker fractions in separate grinding machines. As is shown in Figure 8, the future cement plant will divide clinker into a coarse and a fine fraction by means of classification using a Niagara mechanical screen (see Figure 9). To obtain energy benefits, the coarse fraction is routed to a roller mill for further grinding, and the fine fraction to a ball mill. This achieves an overall increase in specific throughput rate with a simultaneous improvement in the energy-efficiency of the grinding process. The energy savings attained via separate grinding can be as large as 10 %. Further advantages include quieter operation and low wear to the vertical roller mill. For the cement plant this innovative solution allows the highly flexible adaptation to the future demands for standard, special, and blended cement products, and for dry mortar.

5 Conclusion

The cement plant of the future starts in the quarry. The cement quarry of the future will make more products than before, will turn waste into sellable product and it will be more cost effective than ever before. The motto is "let us make more with less". More intensive networking between cement and concrete production and further processing systems could also be advantageous (see **Figure 1**, Cluster I and Cluster IV). Locating concrete production and processing in the vicinity of a cement plant could reduce storage and transportation costs and increase the diversity of products available for regional sales. Let the future begin.

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