BinderTechnology

With High-Tech products to
maximal performance

TILLMAN

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Modern grinding aids can significantly improve the efficiency of grinding equipment. Functional grinding aids or so-called “quality optimizers” can also strongly influence the properties of the final product. The many possibilities and complexity of today’s grinding facilities do make the choice for the best grinding aid a difficult task.

The engineers and technicians in the laboratories of Tillman have the most modern techniques and equipment to their disposal to assist you to make the right choice. The techniques and systems applied by Tillman are among the most modern in the world. Ultra-modern high-tech techniques are used to measure and positively influence properties of materials to grind, where there is always the aim for the best performance and the lowest cost.

With a number of methods developed by Tillman your grinding process can be simulated closely. By using these simulations during the preliminary investigation accomplished for you, the practical tests and the costs for it can be limited to a minimum. Cost-saving, yield-increasing and improving quality are standard objectives of the experienced technicians Tillman.

They are more than happy to take up your specific grinding problem.

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Grindaid TM-I
art 8216

Grindaid TM-IA (con.50)
art 8210

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Product description

Conventional grinding aid based on high-grade amine technology without the binder discolouration and foaming and air entraining which is common for amines. Consistent effect suitable for all types of cement. Due to the high evaporation temperature Grindaid TM type I is highly suitable for high milltemperatures and grinding facilities with widely varying temperatures. The advantageous viscosity index allows a very fast and good distribution on the particle surface, where it reduces the agglomerate building, thereby increasing the grinding action of grinding mills. With this mechanism, the grinding capacity increases and the energy consumption per produced cement volume is reduced. Grindaid TM type I leaves a thin film on the surface of the cement particles which will reduce the mutual adhesion of the particles. Therefore the cement powder is easily transported and bridge - and cone formation in silos is greatly reduced. The flow behavior of the powder facilitates the packaging of the final product and makes packaging equipment run optimally. Special components in Grindaid TM type I ensures good hydration process, thereby increasing the early strength development of the Cement.

Dosage

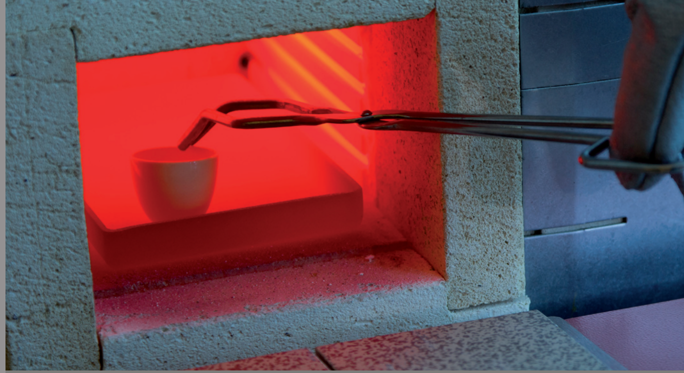
- **Min. dosage:** 0.01% of the material to be ground
- **Max. dosage:** 0.2% of the material to be ground
- **Method of adding and point of time:** during the grinding, drip or spay continuously onto the clinker

Technical data

- **Min. dosage:** 0.01% of the material to be ground
- **State of aggregation:** liquid
- **Colour:** brown
- **Density (kg/l):** ????????
- **pH-Value:** ????????
- **Max. alkali content (% Na2O-eq):** n.a.
- **Max. chloride content (%):** n.a.
- **Colour code:** n.a.
- **Storage:** dry, frost-protected, in closed packaging
- **Shelf-life:** when stored correctly at least 1 year, after date of production

Packaging

Containers, bulk.



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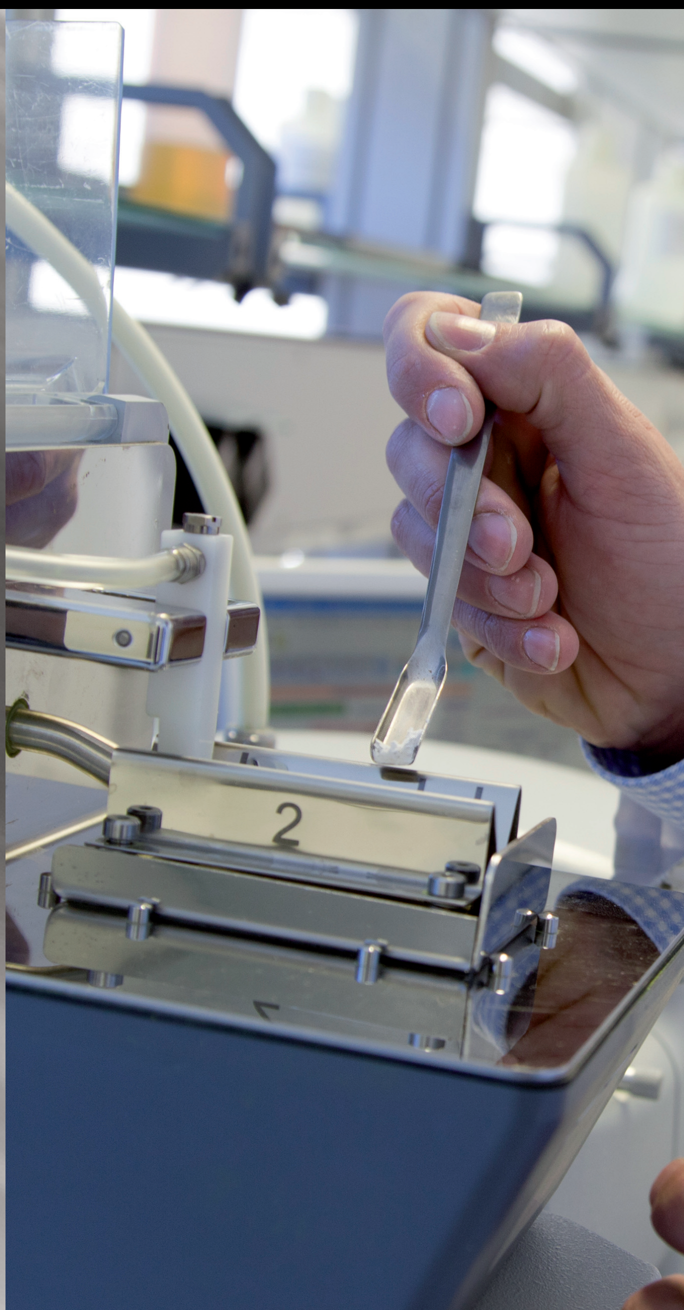
Grindaid TM-II-G art 8212
Grindaid TM-II-GA (con.50) art 8215



BinderTechnology

Grindaid TM-II-G
art 8212

Grindaid TM-II-GA (con.50)
art 8215

Product description

Economical interesting high grade Grinding aid based on the same polymer technology as Grindaid TM II. Excellent performance with almost all cement types. Grindaid TM II G shortens the run time of clinker, slag, limestone, fly-ashes and diverse materials in the mill where cement properties are not influenced negatively. An additional advantage is a lower temperature at higher mill production. The highly effective polymer technology can achieved high yields with low dosages. The dispersive effect allows a significantly reduction of agglomerate forming which has a positive effect on the final degree of hydration.

Dosage

- **Min. dosage:** 0.01% of the material to be ground
- **Max. dosage:** 0.20% of the material to be ground
- **Method of adding and point of time:** during the grinding, drip or spay continuously onto the clinker

Technical data

- **State of aggregation:** liquid
- **Colour:** brown
- **Density (kg/l):** ????????
- **pH-Value:** ????????
- **Max. alkali content (% Na20-eq):** n.a.
- **Max. chloride content (%):** n.a.
- **Colour code:** n.a.
- **Storage:** dry, frost-protected, in closed packaging
- **Shelf-life:** when stored correctly at least 1 year, after date of production

Packaging

Containers, bulk.

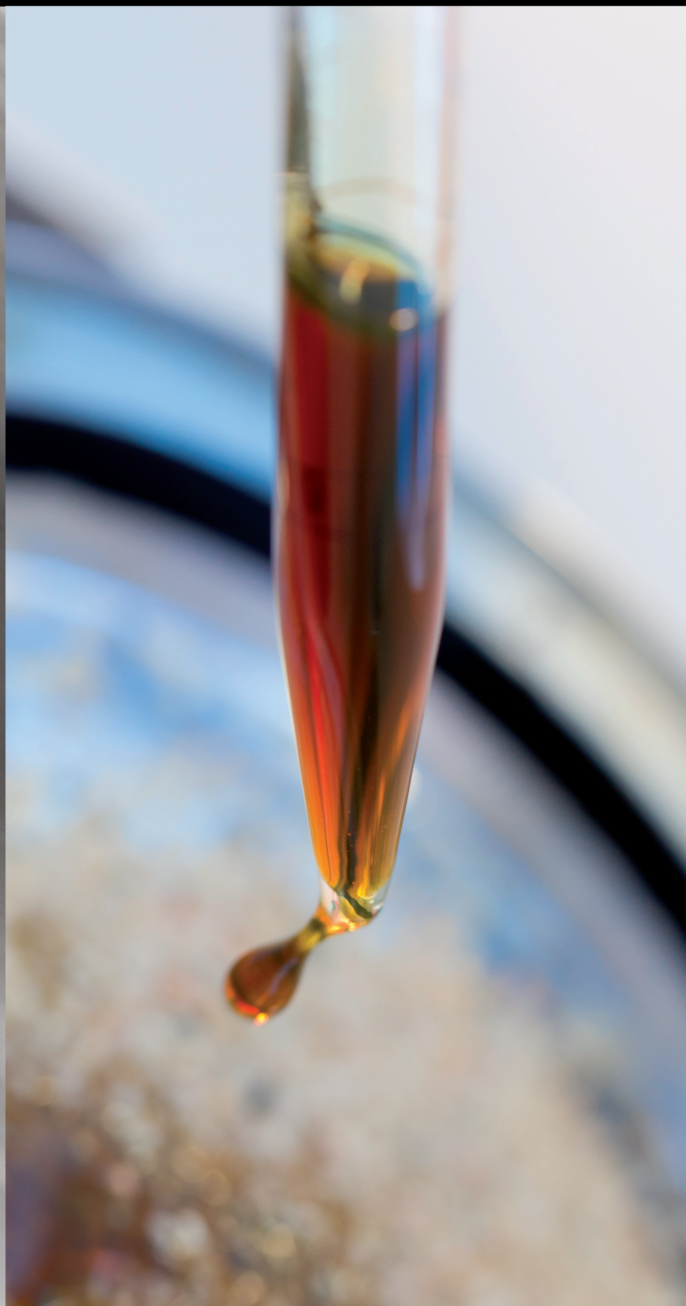
BinderTechnology

Grindaid TM-II

art 8207

Grindaid TM-II-A (con.50)

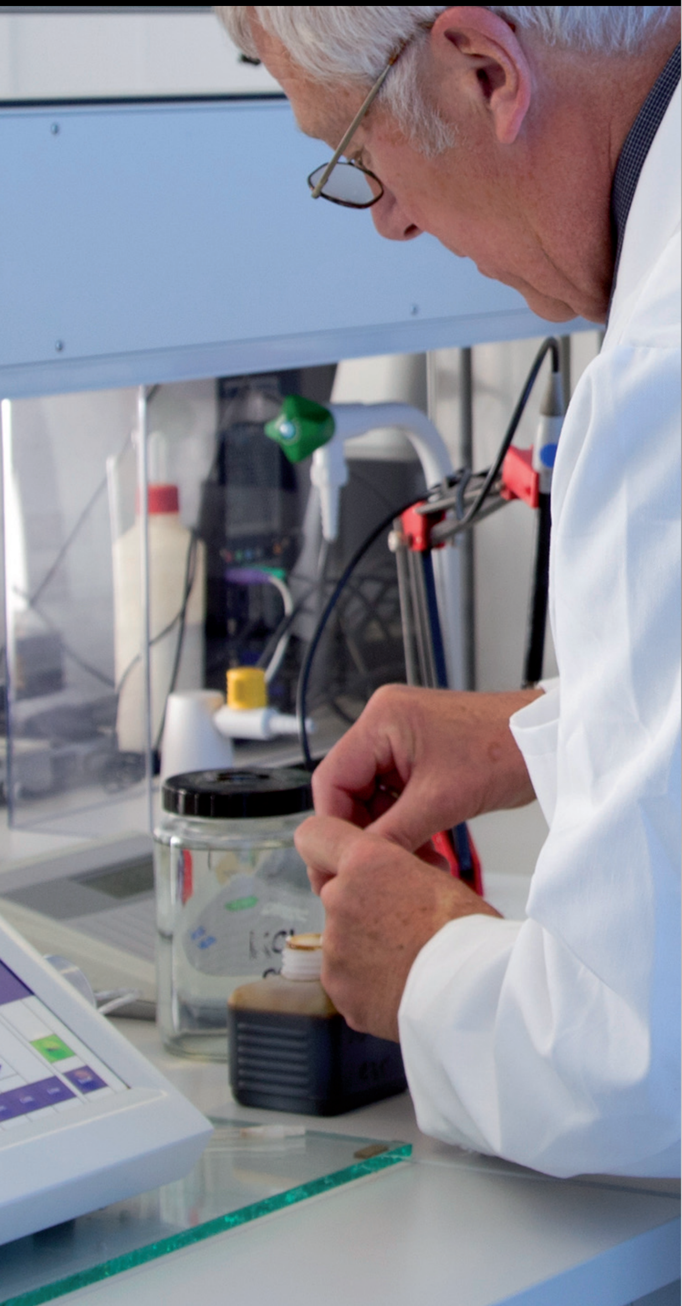
art 8211



BinderTechnology

Grindaid TM-II
art 8207

Grindaid TM-A (con.50)
art 8211



Product description
Grindaid TM II is a high-performance product added during the grinding of cement and slag sand. Grindaid TM II prevents the agglomeration and the static charge of the basematerials during the grinding process. Grindaid TM II enhances the grindability of cement. Compared to other grinding aids, better Blaine values are obtained for the same grinding period at equal dosages. Thus, the residence time in the mill can be reduced, implying increased efficiencyandahigherproductionof cement per hour. The increase in productivity depends, among others, on the clinker to be ground, the type of mill, the mill temperature and the cement class desired. As a rule, the increase in productivity is higher for cement classes 42.5 and 52.5 than for cements of lower strength classes. Grindaid TM II is particularly suitable for the grinding of CEM-III cements. However, a distinct increase in production can also be obtained for CEM-I and CEM-II cements. Cement properties, as for example the water requirement of the cement, are positively influenced. Dependingonthe base material, Grindaid TM II can be used to enhance initial strength development without influencingfinal-strengths. Brown staining, which is frequently caused by the use of other grinding aids, didn't occur up to now. Grindaid TM II doesn't promote corrosion on reinforcing steel (according to DIN V 18988).

Application
Grindaid TM II is used to:
- Enhance the intensity during grinding of cement and slag sand
- Increase Blaine values for egual grinding periods
- Increase production
- Enhance initial strengths
- Limit finalstrengths
- Prevent brown staining of the cement
- Reduce the water requirement of the cement
- Save energy during the grinding process

Dosage
- **Min. dosage:** 0.01% of the material to be ground
- **Max. dosage:** 0.2% of the material to be ground
- **Method of adding and point of time:** during the grinding, drip or spay continuously onto the clinker

Technical data

GRINDAID	TM II	TM II A
• **State of aggregation:**	liquid	liquid
• **Colour:**	brown	brown
• **Density (kg/l):**	1,12	???
• **pH-Value:**	9,6	???
• **Max. alkali content (% Na2O-eq):**	n.a.	n.a.
• **Max. chloride content (%):**	0,1	0.1
• **Colour code:**	n.a.	n.a.

- **Storage:** dry, frost-protected, in closed packaging
- **Shelf-life:** when stored correctly at least 1 year, after date of production

Packaging
Containers, bulk.

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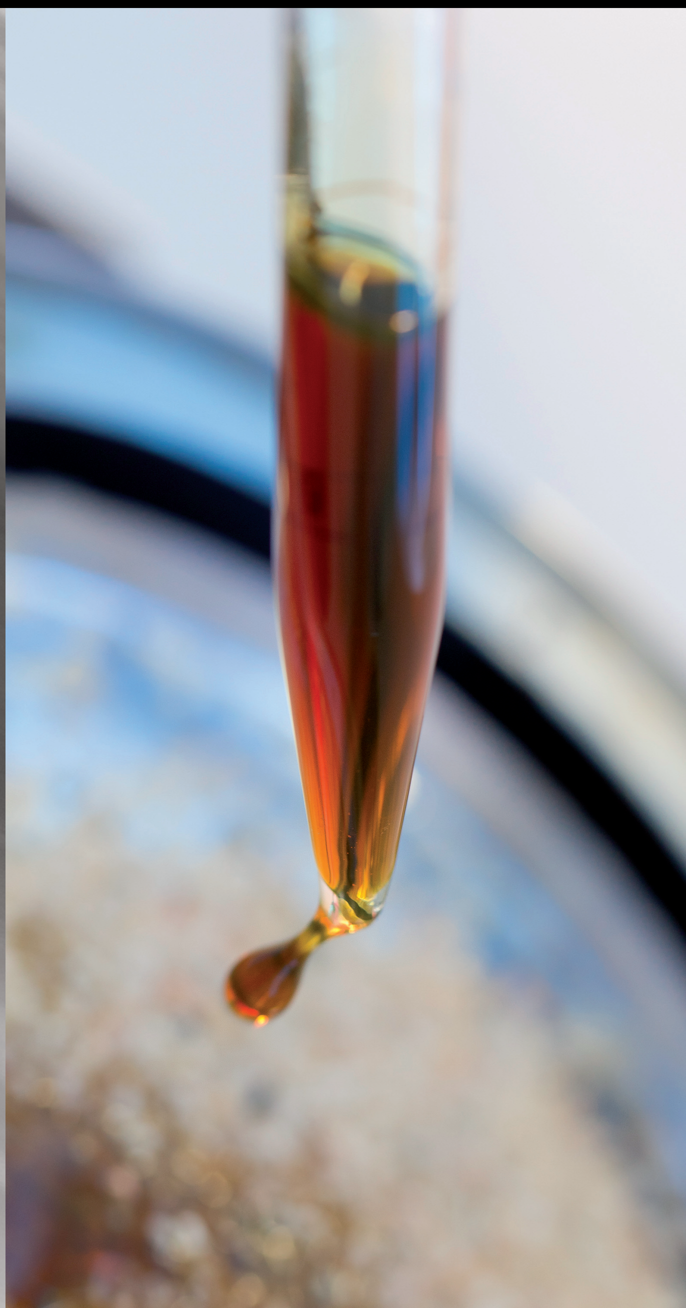

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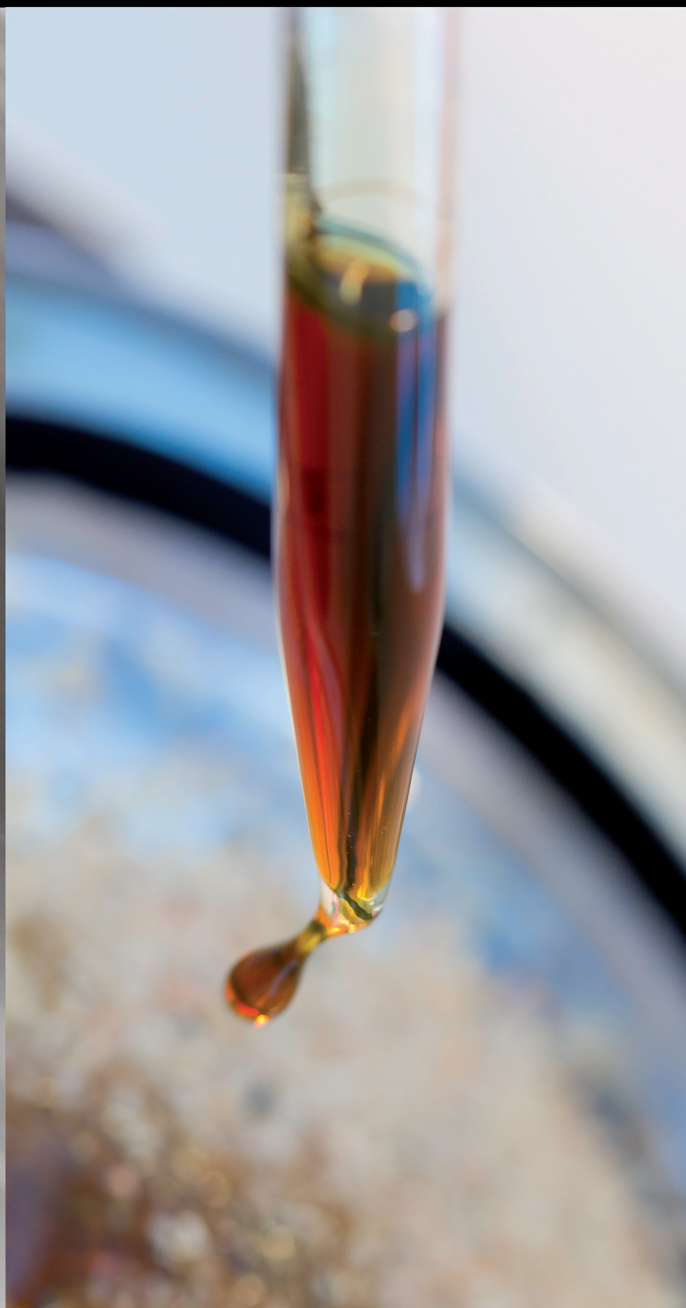

FROM THE GRINDING STATION TO THE WHOLE CEMENT PLANT, OR HOW TO OPTIMIZE THE GRINDING EFFICIENCY

What is cement? Cement is a finely ground manufactured mineral product, gray, consisting mainly of lime and silica, with a small amount of alumina and iron. Cement is produced with various naturally occurring raw materials. In normal use, cement is mixed with water, sand, gravel or other aggregates to form concrete. Although the first attempts to produce cement of natural material date back more than 14,000 years, it was only in the twentieth century that The Man really developed the cement of today.

The first traces of lime mortar have been discovered in Turkey and early forms of cement have been used as far back as the ancient Egyptians, who combined lime and gypsum, in order to build the pyramids. In fact, the first very well known cements were produced by Greeks and Romans from volcanic ash (pozzolana) mixed with slaked lime.

This art was partially lost during the Middle Ages and was not improved upon until 1758, when an Engineer called Smeaton made the first modern hydraulic cement. Portland cement was developed in a small island in the south of england called Portland by English inventor, Joseph Aspdin in early 1800's. This is probably the starting point of the modern cement production with the first rotary kiln designed to produce Portland cement patented in 1885 by Frederick Ransome.

With the industrial revolution and the excessive development of the vast majority of the countries around the world, the cement industry became a huge consumer of energy. The global cement production was around 3,5 billion tonnes in 2011. Taking into consideration an average of 110 kWh to produce 1 ton of cement, the consumption of electricity is approximately around 385 billions of kWh!

The part of grinding represents 65% of the total consumption (≈23% for the grinding of raw meal and 42% for the clinker or finish milling). The world's fleet of grinding machines is divided into four types: Tube mill, Roller Press, Vertical Roller Mill and Horizontal Roller Mill. The grinding efficiency of these machines is very poor (see sheet below) and the greater part of the energy supplied by the absorbed power of the device is lost into heat, vibration, friction wear or sound noise.

Type of Grinding Machine	Grinding Efficiency
Tube Mill	5%
Roller Press	15%
Vertical Roller Mill	10%
Horizontal Roller Mill	15%

In addition, the finish grinding department of a cement plant represents more than 40% of the total consumption and the tube mill, also called ball mill, is still the most common equipment in the world despite the emergence of more efficient devices like the vertical roller mill. And it is also commonly accepted that there is still a great potential for possible improvements regarding ball mills.This is why this technical article will present the different steps of improvments of a small grinding station to become a complete cement plant.

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The three communication laws

Based on approximations and empirical researchs, the grinding theories are explaining the relationship between the process energy input and the increase in material fineness. There are three theories:

- The first one is from **Rittinger**, which says that the created material surface by the grinding process is directly proportional to the energy input. This means that the energy input is inversely proportional to the decrease in particle size. Rittinger's hypothesis can be written in the following form:

$$E = K_1 \times \left(\frac{1}{x_p} - \frac{1}{x_f} \right)$$

where E is the net specific energy,
x_f and x_p are the feed and product size indices,
and K_1 is a constant

- The second one is from **Kick,** which postulates that the energy input is proportional to the particle volume reduction during the comminution process. Kick's equation is as follows:

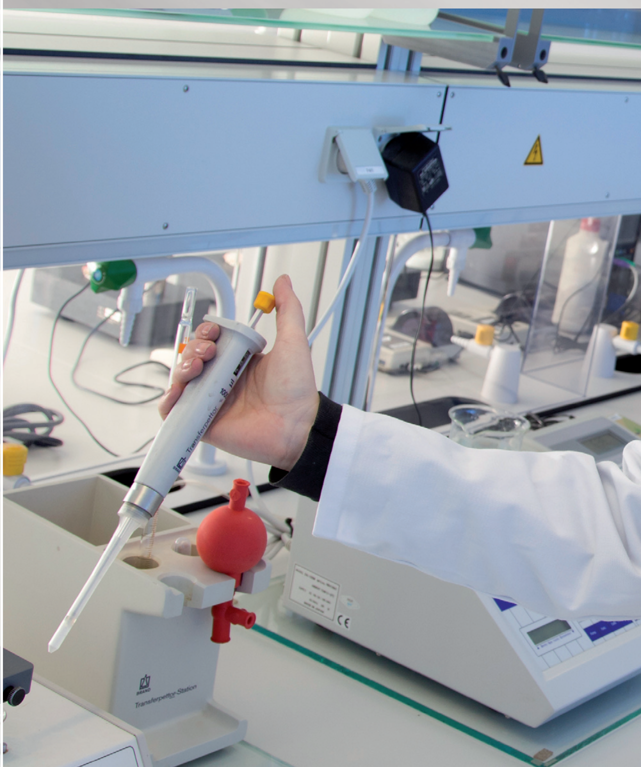
$$E = K_2 \times \ln \left(\frac{x_f}{x_p} \right)$$

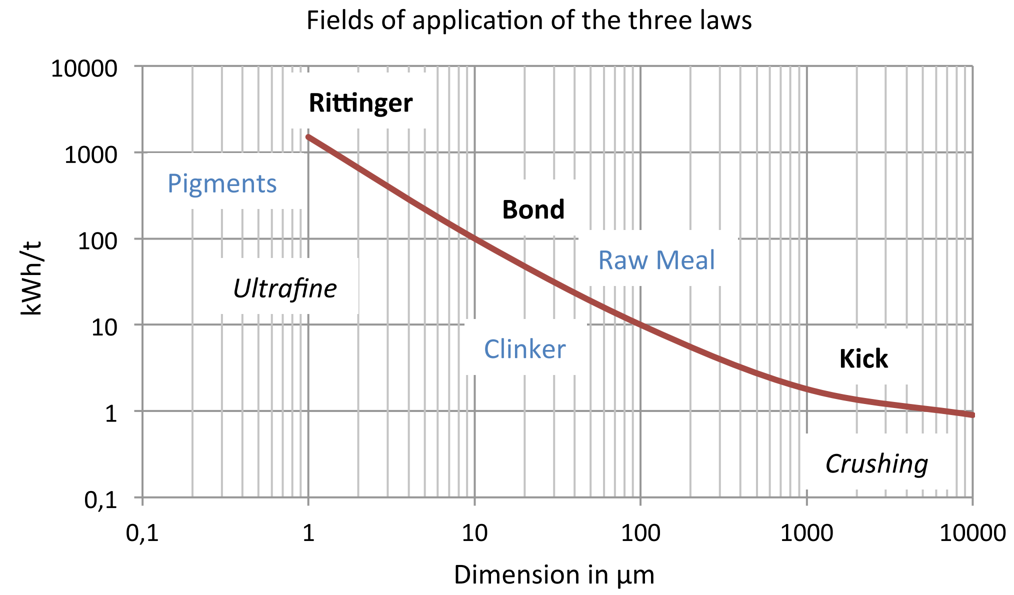
where E is the net specific energy,
x_f and x_p are the feed and product size indices,
and K_2 is a constant

- Finally, the third one was developed by **Bond** and established that the energy input is proportional to the new crack length formed by the comminution process. The Bond law is widely applied in the cement and the mining industry. The equation is:

$$E = K_3 \times \left(\frac{1}{\sqrt{x_p}} - \frac{1}{\sqrt{x_f}} \right)$$

where E is the net specific energy,
x_f and x_p are the feed and product size indices,
and K_3 is a constant





- In the graph below, we can see the fields of application of the three laws in function of the material dimensions. The Y axis gives an idea of the required specific energy in kWh/t.

- From his equation, Bond developed a formula in order to size rod and ball mills, which became the standard. This formula is:

$$W = W_i \times C \times \left(\frac{10}{\sqrt{P_{80}}} - \frac{10}{\sqrt{F_{80}}} \right)$$

where $C = C_1 \times C_2 \times C_3 \times C_4 \times C_5$
where C_1 is a correction for dry grinding,
C_2 is a correction for open circuit,
C_3 is a correction for mill diameter,
C_4 is a correction for feed size,
C_5 is a correction for product fineness.

Bond also established a standard laboratory test in order to define, Wi, the work index.

- And finally, the equation to size tube mills with correction factors is:

$C_1 = 1{,}3$ if dry process

$C_2 = 1{,}2$ if 80% Passing on the required product

$C_3 = \left(\frac{2{,}44}{D} \right)^{0{,}2}$ and $C_3 = 0{,}914$ if D

$$C_4 = 1 + \frac{(W_i - 7) \times \left[\frac{F_{80}}{4000 \times \sqrt{\frac{13}{W_i}}} - 1 \right]}{F_{80}/P_{80}}$$

with F_{80} is sieve size passing 80% of the mill feed (µm),
and F_{80} is sieve size passing 80% of the mill product (µm).

$C_5 = \frac{P_{80} + 10{,}3}{1{,}145 \times P_{80}}$ if $P_{80} < 75\mu m$

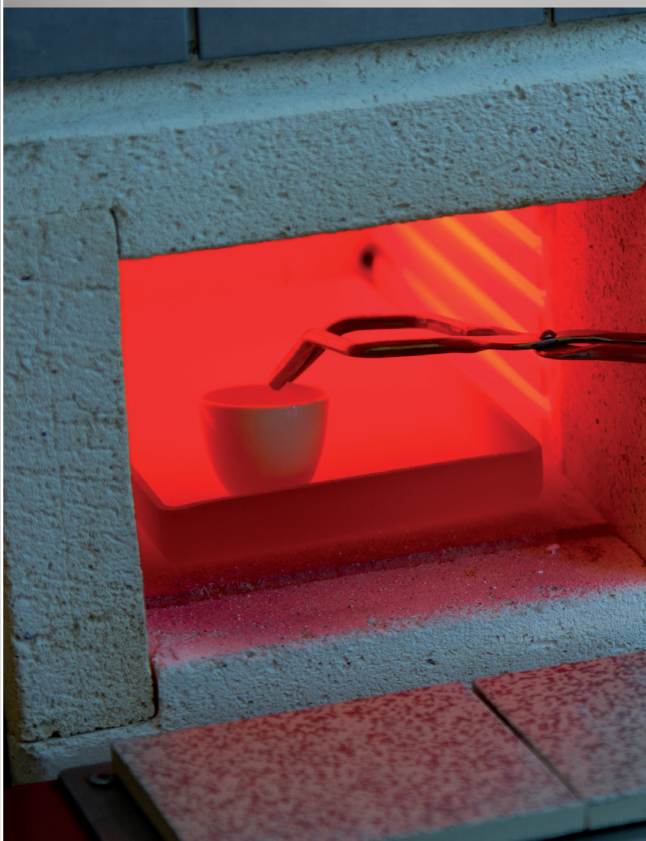
The sizing of the Grinding station

Let's call the owner of the new grinding station: The Engineer. Various equipments had already been installed as silos for clinker and gypsum, cement silo and conveyor belts. Was missing the ball mill to produce a Portland cement type CEM I 32,5 with 95% of cement and 5% gypsum. The clinker should come mainly from a cement factory located 120 km away. There, the clinker was produced in a Lepol kiln. It means that the granulometry was very steady in the time with a majority of grains between 9 and 10mm. It was also recognized that the grindability and the hardness of the Lepol system clinker were very good.

The clinker had the following properties:

Data Name	Data Value
%C3S	54
%C2S	16
%C3A	9
%C4AF	10
Dimension maxi.	20mm
80% of Passing	10mm
Grindability	Good
Bond Work Index Wi	14,85 kWh/t
Hardness	Soft clinker

In function of these data, The engineer calculated the size of the mill he needed to produce 50 t/h of cement at 3200 Blaine with 3,5% residue on 90µm and 80% of passing on 41µm. The Bond formula gave a necessary energy of 35,83 kWh/t. This specific energy multiplied by the production (35,83 x 50) gave the absorbed power needed: 1791 kW. As the project was considering an open circuit, The Engineer was looking for a ball mill with a L/D ratio equal to 3,5.



Name	Dimension	
Diameter	3,5 m	
Length	11,375 m	
Installed Power	2000 kW	
Rotation	17,41 rpm	i.e 77% of the critical speed
Chamber 1 Length	3,5 m	33% of the total (Usefull length)
Chamber 2 Length	7,5m	(Usefull length)
L/D ratio	3,25	Normally, should be 3,5 for open circuit

The second hand mill finally selected had the following dimensions:

The L/D ratio was a bit lower than the optimum value but the cement fineness target was not so high, then The Engineer was not preoccupied. The cement mill was equipped with the following mill internals:

Compartment 1:
- Feed end liners
  (to protect the mill heads against wear)
- Lifting lining (STEP type)
- Single separation diaphragm
  (with 8mm slots in the grates)

Compartment 2:
- Plate lining without classification effect
- Outlet diaphragm (with 8mm slots in the grates)

The following step was to fill the ball mill with steel balls. The supplier recommended the following ball charge taking into consideration that the second chamber lining was not classifying:

Chamber 1			Chamber 2		
Diameter	tonnage	%	Diameter	tonnage	%
90 mm	4 t	9,5	25 mm	35 t	37,6
80 mm	16 t	38,1	20 mm	10 t	10,7
70 mm	17 t	40,5	17 mm	14 t	15,1
60 mm	5t	11,9	15 mm	34 t	36,6
Total	42t	100	Total	3 t	100
	30%VL			30%VL	
Average	1586 gr/t		Average	23,1 gr/t	

And finally, The Engineer chose a bag filter and a fan for the mill ventilation with the following basis:

- to insure the cooling of the mill and the material
- to dedust the mill
- to sweep the fine particles out of the mill

Values for an open circuit mill (calculated in terms of air velocity in the free section of the mill) are between 0,8 and 1,2 m/sec. Let's take 1,2 m/sec as reference. The Engineer used the formula below to define the air quantity required:

$$Q = \left(\frac{\pi}{4}\right) \times \left(D - \frac{2 \times e}{1000}\right)^2 \times \left(\frac{100 - j}{100}\right) \times v \times 3600 \times \left(\frac{100 - f}{100}\right) \ in \ {}^{m^3}/_{h}$$

where D is the mill diameter in m,
e is the lining thickness in mm,
j is the volume load in %,
v is the air speed in m/sec and
f is the false air at mill outlet in %

With e = 68mm, j = 30,1%, v = 1,2m/sec and f = 15%, one finds: 30.864 m3/h (fan of 34.000 m3/h were chosed). Pressure drop available to the fan, The Engineer calculated 160mmWG for the mill, 150mmWG for the bag filter, 60mmWG for the ducts and 20mmWG for the dynamic pressure, that to say a total pressure drop of 390mmWG.

Flow-sheet of the installation:

The last step before start up the installation was the calculation of the water injection required in the second chamber of the ball mill in order to keep the right cement temperature. The first hypothesis was the temperature of the clinker that The Engineer estimated at 50°C (coming from outside). The result was that it was necessary to inject 300 l/h in order to maintain a temperature of 105°C. A water injection system was installed.