Optimized crusher selection for the cement industry

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The characteristics of raw materials required for the cement production differ at a wide range. The limestone deposits used today as base material, show very different properties regarding hardness, abrasiveness and stickiness. To optimize the crushing process as well as the investment and operating costs, different types of crushers are available. To make a proper selection, several important points should be considered in advance.

The very first step should always be an analysis of the quarry, and especially the characteristics of the raw material. Of prime importance is the hardness of the material to be crushed. To describe this property the compressive strength, the Los Angeles Index or the Mohs Hardness should be determined and a point load test should be carried out.
The abrasiveness of the material has to be described by its Silica and free quartz content, as well as the abrasion index. Just as important is an expression of the stickiness. For this reason the moisture, the clay content and, in very difficult applications, the handling coefficient (shear test) has to be ascertained. Based on this data an overview of the selection criteria allows a pre-choice of the required crusher (Fig.1).

Primary crushing of limestone for the cement production requires high crushing ratios to reduce the material in a single step, down to the required grain size (approx. 0 – 25/80mm) for the raw mills. It should always be the aim to have as few crushing steps as possible, in order to minimize the investment and maintenance costs and time. According to the above overview, one step crushing can be achieved by operating Hammer Crushers or Impact Crushers. These crusher types are fast running machines providing high kinetic energy, resulting in strong impact forces and high crushing ratios. The allowable maximum compressive strength of 150 Mpa is normally sufficient for most of the limestone applications.
The silica content is an important issue to be considered before using Hammer or Impact Crushers. Due to the high speed of the rotors, the crushing tools (hammers or impact bars) are vulnerable to wear.
The limit for these machines is 8-12% silica content. Before making a final decision, the abrasiveness of the raw material has to be analyzed very carefully to avoid suffering from high maintenance costs.

If the silica content is above mentioned values, a crushing system with a small speed difference between the material to be crushed and the crushing tools should be used.
As final material characteristics, the moisture content has to be taken into account.
While the Impact Crusher is limited to a moisture content of max. 8%, the Double Shaft Hammer Crusher can take on a moisture content of up to 20%.
This special feature allows charging limestone and sticky materials like e.g. clay at the same time, to obtain a pre-homogenization within the crusher.

Wherever the silica or the moisture content is too high for hammer or impact crushers, a two-step crushing system is a better solution for reducing the material to the requested grain size for the raw mills.
Available for these two-step systems are Double Roll Crushers, RollSizers, Jaw Crushers and Gyratory/Cone Crushers, which are all able to operate in abrasive material. But while the crushing ratio of these crushers is approx. the same (1:5 to 1:6), their ability to crush hard and/or wet material differs.
Jaw and Gyratory/Cone crushers reduce the material by high pressure, which makes them perfect for processing hard materials with a compressive strength of up to 400 Mpa. Because of the relatively low compressive strength of limestone (< 150 Mpa), these crushers are mainly used for highly abrasive limestone. On the other hand these machines are sensitive to high moisture contents, which have to be considered very carefully.

Double Roll Crushers and RollSizers combine pressure and impact, as well as shear and tensile forces for crushing. They are limited regarding hardness of the material (max. 175 Mpa), but they are able to crush very sticky and abrasive materials.

The previously given explanations show, that for every kind of limestone there is a suitable crusher combination to produce the required grain size distribution.
But not only for limestone, also for the necessary additives (like e.g. clay, lime, puzzolan, sandstone, iron ore, schist etc.) with their different material characteristics, the proper crushing method can be realized.

Impact Crushers

With the introduction of vertical roller mills, which accept a raw material size of up to 80mm, the Impact Crusher became of prime importance for the cement industry. Modern Impact Crushers are equipped with heavy duty rotors in common rail design. Specially designed cast discs are combined on one main shaft, concentrating the main weight at the circumference of the rotor. The result is a high moment of inertia and kinetic energy, which allows one-step crushing of the raw material down to the required product size.

State-of-the-art Impact Crushers are equipped with hydraulically supported impact walls and grinding path, allowing a calibration of the crushing gap and the product size according to the requirements. Therefore one crusher can be sufficient to produce limestone with a grain size of 0/80mm for the raw mills and a grain size of 0/35 mm as additive for the cement mills.
To meet the problem of having uncrushable material like e.g. tramp iron in the feed material, each Impact Crusher should be equipped with an effective overload protection.
ThyssenKrupp Fördertechnik achieves this by a patented combination of the grinding path and the lower impact wall (Fig. 3).

As soon as an overload occurs at the lower impact wall, the supporting cylinder is released and the gap between impact wall, grinding path and rotor is being widened. This avoids any damages to the grinding path by opening the gap before the tramp iron passes through. After discharging the uncrushable material to the discharge conveyor, the hydraulic cylinders move the impact wall and the grinding path back to the former position.
Maintenance-friendly details like interchangeable wear plates, quick release bolts for very fast opening of the housing, hydraulically fixed blow bars, blow bar lifting and rotor positioning devices are also standard items of recent impact crushers.

Double Shaft Hammer Crushers

The main crushing process of a Double Shaft Hammer Crusher is performed by rotating hammers between the rotor and on the anvil. It is important to understand, that the material is not 'ground' on the grate baskets. The grate baskets calibrate the material grain size by different openings, in order to produce raw material either for ball mills (0/25 mm) or vertical mills (0/80 mm).
Double Shaft Hammer Crushers are used in the cement industry to solve crushing problems in difficult materials like wet limestone combined with clay. This capability to operate under such severe conditions without clogging problems is achieved by the self-cleaning effect of this machine, which results from the fact that the material is mainly in contact with rotating elements. Only the grate basket to calibrate the final grain size is fixed but also cleaned by the rotating hammers. Of course the entire crushing chamber geometry, the design of the anvil and the grate baskets have to be optimized and adapted to avoid clogging problems. The advantage regarding the non-clogging effect of the Double Shaft Hammer Crusher is illustrated in Fig. 5.

Impact Crushers and Single Shaft Hammer Crushers crush the material by impact of the blow bars or hammers and by throwing the material against fixed side walls, which are not cleaned. The Double Shaft Hammer Crusher works like a Double Roll Crusher, where the material is only in contact with moving, self-cleaning crushing tools.
The ability to crush sticky materials allows the simultaneous feeding of several materials by means of two or three apron feeders, causing a pre-homogenization within the crusher.

Double Roll Crusher and RollSizer

Despite of their low crushing ratio both Double Roll Crusher and RollSizer are used
in the Cement and lime Industry.
Unlike the impact and hammer crushers with their high rotor speed, the roll crushers operate at low speed, producing a minimum of fines content. This fact makes these machines especially suitable for the lime production, where a maximum of stones for the kiln is required. But also under difficult conditions like extremely sticky (clay) or abrasive (clinker) material this type of system is the perfect solution, thanks to low operating speeds and non-clogging effect.

Because limestone is mainly not very abrasive or extremely sticky it can be crushed in one step and the Double Roll Crusher and the RollSizer are rarely installed as primary limestone crusher. But especially regarding additive processing they are important, in order to achieve an economic crushing solution.

Jaw Crusher and Gyratory/Cone Crusher

Jaw Crushers and Gyratory/Cone Crushers are the perfect choice for hard rock applications. They can be used for very abrasive but dry and non-sticky materials with a compressive strength of up to 400 Mpa. Their crushing ratio is relatively low, compared to Impact and Hammer crushers, thus for primary limestone applications a two step crushing system is necessary.
Because of that, they are rarely used for the production of main material for raw mills.
Just like Roll Crushers these systems can minimize the fines and maximize the stone content in the crushed product to be used in the lime production. Additives like e.g. iron ore can also be processed perfectly with Jaw and Gyratory Crushers.

Conclusions

Although the materials used for the cement production are quite different regarding hardness, abrasiveness and stickiness, there is a wide range of crushers and crushing systems available, meeting all requirements. They allow the optimization of each crushing process and thus a minimization of investment and operating costs.

ThyssenKrupp Fördertechnik - Produktprogramm Auswahlkriterien für Brechsysteme					
Brechertyp		Maximaler Zerkleinerungs-grad	Druck-festigkeit [Mpa]	Quarz-anteil [%]	Feuchtigkeits-anteil [%]
Einwellen-Hammerbrecher		1 : 100	< 150	≤ 8	< 10
Doppelwellen-Hammerbrecher		1 : 100	< 150	≤ 8	< 15 - 20
Prallbrecher		1 : 20 1 : 60 Mahlbahn	< 175	≤ 12	< 8
Walzenbrecher		1 : 6	< 150	> 15	> 20
RollSizer		1 : 6 primär 1 : 5 sekundär 1 : 4 SideSizer	< 175	> 15	> 15 primär < 15 sekundär < 15 SideSizer
Backenbrecher		1 : 5	> 150 - 400	> 15	< 5
Kreiselbrecher		1 : 5	> 150 - 400	> 15	< 5

Bild 1: Überblick Brechsysteme

Product Range of ThyssenKrupp Fördertechnik Selection Criteria for Crushing Equipment					
Crusher Type		Max. crushing ratio	Compressive strength [Mpa]	Silica content [%]	Moisture content [%]
Single Shaft Hammer Crusher		1 : 100	< 150	≤ 8	< 10
Double Shaft Hammer Crusher		1 : 100	< 150	≤ 8	< 15 - 20
Impact Crusher		1 : 20 1 : 60 Grinding path	< 175	≤ 12	< 8
Double Roll Crusher		1 : 6	< 150	> 15	> 20
RollSizer		1 : 6 primary 1 : 5 secondary 1 : 4 SideSizer	< 175	> 15	> 15 primary < 15 secondary < 15 SideSizer
Jaw Crusher		1 : 5	> 150 - 400	> 15	< 5
Gyratory Crusher		1 : 5	> 150 - 400	> 15	< 5

Fig. 1: Crusher overview

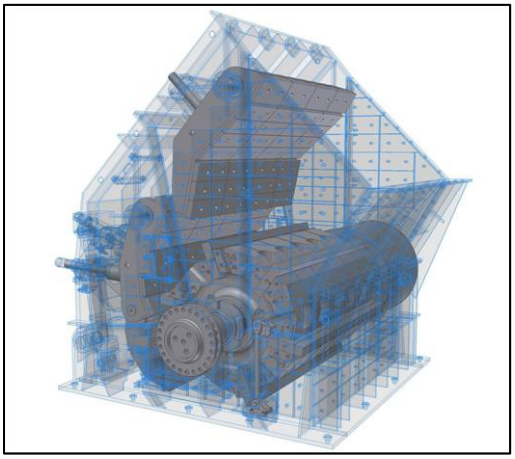

Bild 2: Prallbrecher mit Gussrotor

Fig. 2: Impact Crusher with cast rotor

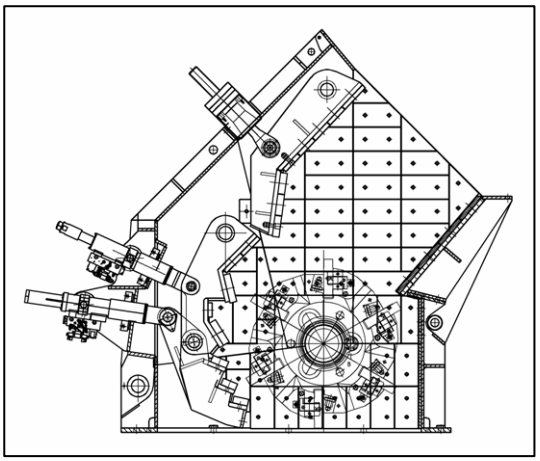

Bild 3: Prallbrecher

Fig. 3: Impact Crusher

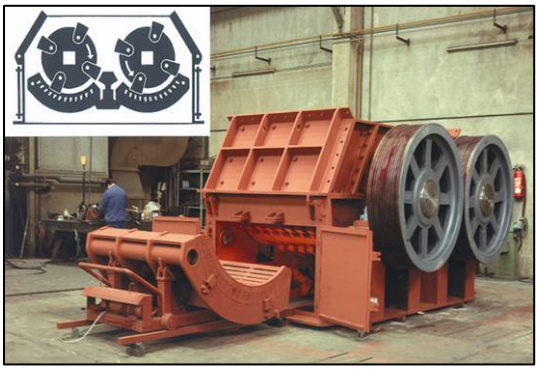

Bild 4: Doppelwellen-Hammerbrecher mit Rostkörben

Fig. 4: Double Shaft Hammer Crusher with grate baskets

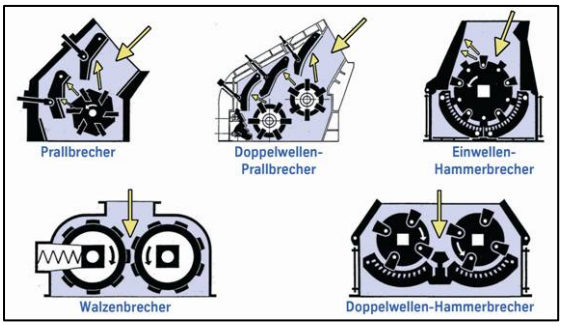

Bild 5: „Non-clogging effect“
des Doppelwellen-Hammerbrechers

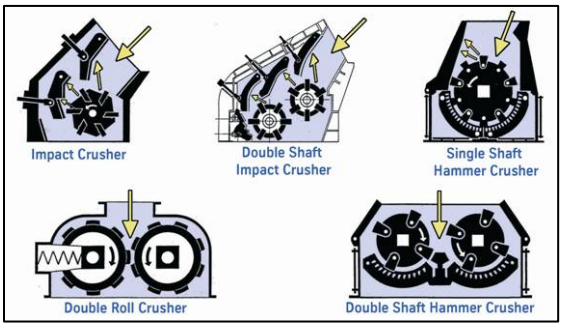

Fig. 5: Non-clogging effect of Double Shaft Hammer Crusher

Bild 6: Brechanlage mit drei Plattenbändern

Fig. 6: Crushing installation with three apron feeders