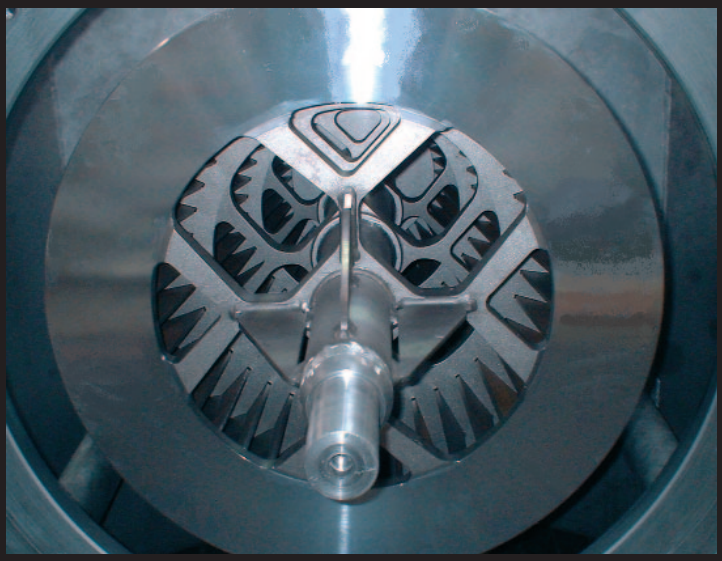
Dry GCC

Fine...finer... extra fine

When processing calcium carbonate, a variety of different grinding and classifying systems are needed to cover the entire range of particle sizes required. Here, *Miha Kirn, Robert Rosen,* and *Bodo Furchner* describe two systems designed by Hosokawa Alpine and operated by Calcit d.d. which achieve just that.



Wheel of a production size Turbotwin Classifier.
All pictures courtesy Hosokawa Alpine Aktiengesellschaft

THE PROCESS of size-reduction begins in the quarry where the material is crushed, and continues under application of different stressing mechanisms. Initially, impact crushing is employed, i.e. impact crushers and hammer mills. However, depending on the purity of the deposit, impact crushing does not have to be restricted to the coarse range, as if the feed product is extremely pure, cost-effective operation is also possible with pin mills and mechanical classifier mills. In such cases, end products with a top size (x_{97}=97% cumulative undersize fraction) far below 100μ can be achieved.

Where high throughputs are necessary, the table roller mill constitutes a cost-effective alternative when producing fillers in the range below 100μ, especially if the raw material contains hard impurities. The mill utilises compressive stress in the material bed, and reacts immediately to changes of operating parameters making it extremely flexible in production. Table roller mills from Hosokawa Alpine are capable of producing finenesses down to 10μ. However, in order to achieve this, the speed of the grinding table must be reduced causing the capacity of the system in the ultrafine range to decrease somewhat. Because of this, the forte of table roller mills is in the range of around 20μ and coarser.

If even finer fillers are required, then mills with grinding media, i.e. ball mills and agitated pearl mills, are the only alternative. In these mills, the particles are primarily broken down using friction. In spite of being on the market for well over 100 years, the ball mill is still state of the art, and optimum operation is guaranteed in the range between 6 and 100μ. In the ultrafine range, i.e. at high specific grinding energy input and long residence times of the material in the mill, a reduction in quality in the case of high-grade fillers occurs owing to iron contamination. For this reason, customers are increasingly going over to the dry ATR agitated pearl mills for operations in the highest fineness range.

The following examples present two systems manufactured by Hosokawa Alpine, and operated by Calcit d.d. in Slovenia.

Keeping it simple

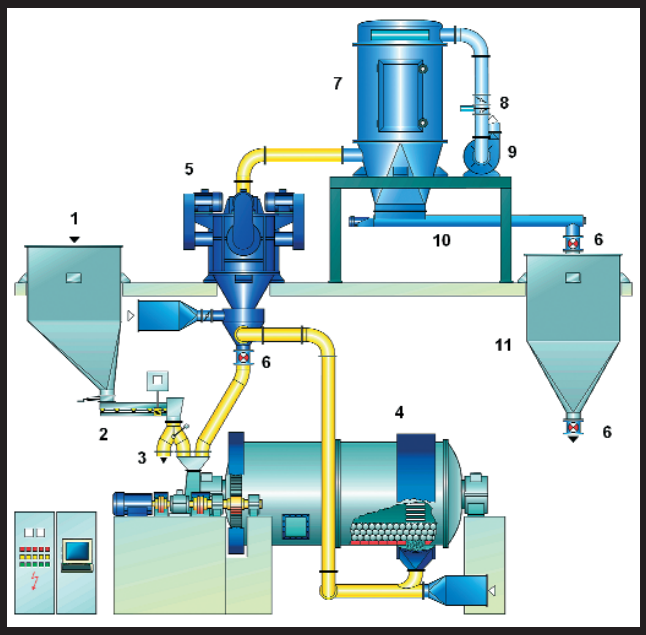
According to recent findings originating from the cement processing industry, the grinding media used in ball mills for ultrafine comminution should be as small as possible. However, it is important to note that the use of even smaller grinding media in a large ball mill quickly reaches the limits of cost-effectiveness because of the high costs of the ball charge.

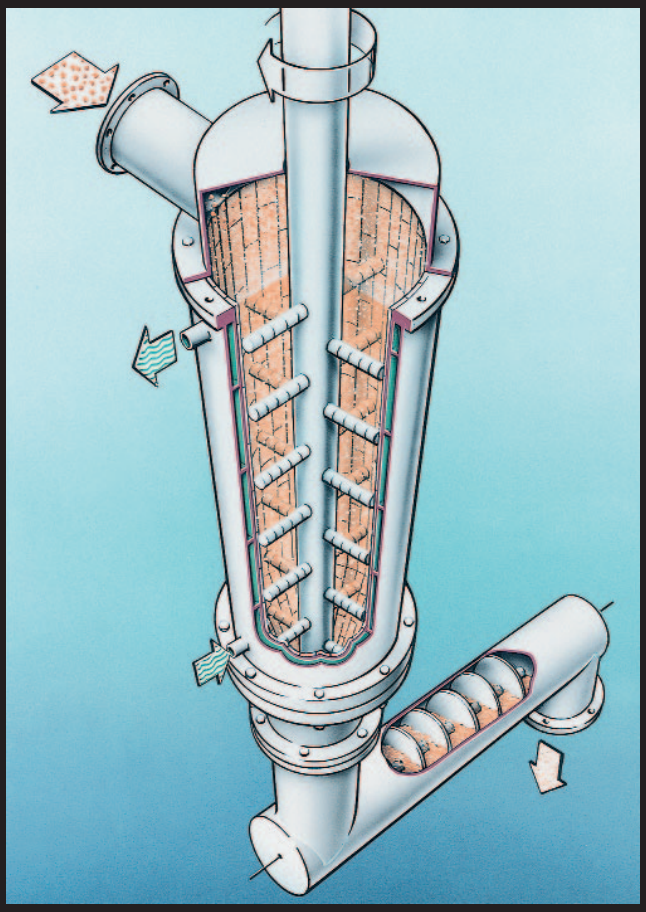
Consequently, for some time Calcit has been using small cylpebs for grinding fine limestone fillers, which requires that the feed material fed into the ball mill should not be too coarse, with 5mm as an upper limit.

A further consideration of milling is that in a range where the product fineness exceeds 10μ, calcium carbonate is usually fairly easy to

The Turboplex® multi-wheel classifier 630/4 ATP can provide finer classification without having to increase the speed of the classifying wheels.

Flow chart for a ball mill system with ATP Turboplex® multi-wheel classifier
1 Feed bin 2 Feeder 3 Diverter flap 4 Super Orion ball mill S.O. 5 Turboplex® air classifier ATP 6 Rotary valve 7 Dust collector 8 Air flow control 9 Fan 10 conveying screw 11 product silo





Schematic of the dry agitated ball mill ATR. The ATR can achieve an impressive power density ratio, which reduces the amount of grinding media required

process, whereas in the finer range, attention must be paid to the moisture content of the feed material. Here approximately 0.5% moisture is usually optimal, as a moisture content that is too low or too high can create problems.

As simplicity is important, Calcit has always pursued the concept of a system configuration that is as straightforward as possible, i.e. one mill and one classifier. Even with large ball mills and high finenesses, this concept is attainable through the use of Hosokawa Alpine's Turboplex® multi-wheel classifiers 500/4 ATP and 630/4 ATP.

For transportation of the product between the mill and classifier, Calcit use a pneumatic transport method as opposed to a bucket evaluator. Because the product exiting the mill is well dispersed, it has no opportunity to form agglomerates and retains this disperse condition until it reaches the classifier, which alongside saving the costs for a bucket elevator, also leads to sharper cut. The addition of grinding aids increases the performance of the system even more, however, the presence of grinding aid in the final product is not always acceptable.

The ball mill used in this example is 3 metres in diameter and 5 metres in length, and has a nominal ball charge of 46 tonnes and a 630-kW drive, of which about 550kW is used for mechanical power in the drum during mill operation.

Discharged from the mill through slots in the housing, the product is conveyed to the 630/4 ATP classifier pneumatically. The 630/4 ATP is a deflector-wheel classifier in multi-wheel design. The multi-wheel design with relatively small classifying wheels brings the advantage of a finer classification without having to increase the peripheral speed of the classifying wheels. This has a positive effect on the pressure drop and wear rate. The flow of ground material from the mill to the classifier is between 25 and 60t/h, depending on whether the aim is a fine or a coarse product. The circulation factor is therefore between 3 and 4 and can be set by opening or closing the discharge slots.

The air classifier has 4 classifying wheels of 0.63 metres in diameter and is operated with a total air flow of approximately 55,000m3/h. A fan with 500kW motor is installed to operate the air classifier and 4 x 45kW are installed in addition at the classifier wheels, making it quite clear that when it comes to fine fillers, the energy for the classification process is not much lower than that for the comminution process.

Table 1: Performance data for the ball mill S.O. 300/500 with Turboplex® multi-wheel classifier 630/4 ATP

	Degree of whiteness	Fineness x_{98}	Fineness x_{50}	Throughput
Calplex 2	94	10 µ	2.5 - 3 µ	10 t/h
Calplex 5	93	20 µ	5 - 6 µ	18 t/h

Slowly but surely

The Agitated Dry Pearl Mill 900 ATR is a low-speed dry processing unit. In spite of the fact that the peripheral speed is only 2m/s the machine achieves a power density of up to 180kW/m3, which is an impressive figure when compared to a ball mill in ceramic design which typically operates at one-tenth of this value. Therefore, the ATR only requires 10% of the grinding pearls that would normally be used in a comparable ball mill of ceramic design, making the use of small grinding pearls of 5mm in diameter possible. Here too, smaller pearls lead to an energetically more favourable grinding process, especially in the case of ultrafine fillers.

The mill itself is completely protected against wear and contamination. The

mill shell is cooled with water, although this measure is more to protect the adhesive used for the aluminium oxide lining than to remove heat from the product.

Because of the small grinding media, the feed product for the agitated pearl mill must be smaller than 100μ. With the agitated pearl mill in combination with a Turbotwin Classifier 500 TTC, ultrafine fillers can be produced. A cumulative fines portion of 90% < 2μ, i.e. a fineness suitable for use in cable insulating material or paper, can be produced with this system on a production scale. The high portion smaller than 1μ in the product of the agitated ball mill make it necessary to always operate the mill with grinding aids.

With the agitated pearl mill ATR, a mixture of grinding pearls and product is discharged from the mill by a screw in a continuous process, a factor that has the advantage of allowing all materials even those with poor flow properties, to be processed. Furthermore, this process allows the grinding pearls to be cooled externally, a factor that is significant as owing to the high power density of the machine, the grinding pearls do become quite hot. This is important as if the degree of whiteness of the end product is to remain as high as possible, the temperature when processing calcium carbonate should not exceed 80°C.

The mixture of grinding pearls and product is separated by a simple sieving machine. The pearls are returned to the mill via an intermediate bin and a bucket elevator, whereas the product is conveyed pneumatically to the air classifier. The coarse material exiting the classifier is returned to the mill for further comminution with the same bucket elevator.

Several years of development work were invested in a new air classifier which could run at higher speeds than the Turboplex® without increasing the pressure drop, and maintaining its good separation efficiency. The result of this development was the Turbotwin air classifier with a long cylindrical classifying wheel which is supported by bearing units on both sides of the wheel. This design permits higher peripheral speeds of the wheel than the cantilevered design of the Turboplex®, resulting in higher finenesses. However, the higher peripheral speed in general would generate a higher pressure drop. This was combated with a new, patented design of the wheel vanes, resulting in a pressure drop no higher than that of the Turboplex® even at the highest wheel speeds.

The 900 ATR mill installed at Calcit has a grinding chamber volume of 2.2m^3 and a drive power of 315kW. The 500 TTC classifier with 500mm classifying wheel diameter is powered by 75kW, the speed of the classifying wheel is adjusted by means of a frequency converter to the desired fineness. The air classifier is operated at an air flow of 16,000m^3/h. A powerful fan is also necessary to operate the classifier, namely 132kW.

Besides the 500 TTC classifier a second classifier is installed in the system. The two classifiers allow the production of two products at the same time: either Calplex Extra plus Calplex 1 or Calplex 0 plus Calplex 1.

Table 2: Performance data for the Agitated Dry Pearl Mill 900 with Turbotwin Classifier 500 TTC

	Degree of whiteness	Fineness x_{98}	Fineness x_{50}	Throughput
Calplex Extra	96	3,5 μ	0.75 – 0.9 μ	0.7 t/h
Calplex 0	95	4 μ	0.9 – 1.1 μ	1.3 t/h
Calplex 1	95	7 μ	1.5 - 2 μ	2.5 t/h

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Hosokawa Alpine will also be speaking at the 6th Industrial Minerals Conference (CIMC6) with a paper on the economical mass production of mineral slurries for the paper industry. Running from 18-20 September, CIMC6 is part of the Chinese Industrial Minerals Week in Shanghai. For more details see page 47.

Dry processing in China

A new option for improving quality

At the moment, many dry producers of kaolin in China are following the traditional multi-step processing method shown below:

40mm feed
⇩
Roller Mill to 45 μ
⇩
Wet milling (using a number of wet grinders) to produce a product 88-90% <2 μ (high content <0.8 μ)
⇩
Spray drying
⇩
Mechanical desagglomeration
⇩
Calcination
⇩
Mechanical desagglomeration
⇩
Classification (optional) to remove oversized particles

Besides the number of processing steps which utilise a huge number of machines, the achievable quality is also not ideal. End products often contain too many fines, with the top cut rarely reaching the required fineness, as the desagglomerator cannot always destroy the hard agglomerates created during calcination and classifiers are often unsuitable to provide the correct cut below 2μ.

However, it is also important to look at the overall energy consumption, which due to the wet grinding stage is relatively low. Furthermore, energy intensive drying can be effected in China very economically due to the availability of cheap coal. Although dry processing beats wet, with a lower content of fines <8μ, and higher fineness of 92-94% <2μ, the energy consumption must also be kept in an acceptable range to be competitive.

Hosokawa has improved the dry ball mill/classification process with its Super Orion Super Fine Ball Mill SO-SF in a closed circuit with the Alpine Turboplex Multiwheel classifiers. This combination is able to achieve 10% fewer fines at 0.8μ at a higher fineness of 93% below 2μ. In addition, the result can be obtained at an electrical energy consumption which is slightly lower than the traditional process.

Overall, due to the finer top cut before calcinations the end product quality is in the required specification. A further advantage is to replace the three processing steps with one. Where a high specification is needed, an Alpine Turbo Twin Classifier can give a last cut below 2μ.

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