Deliberate crushing of tablets

An examination of the particle size distribution of microcrystalline cellulose Oblong tablets during grinding or de-agglomeration through a conical sieve mill with round screen hole sizes 5 mm, 2.5 mm, 1 mm and 0.6 mm.

As in any production, tablets can also be produced with defects. If the tablets are too hard or too soft it can have a direct influence on the effect of the incorporated substance on the patient / consumer. Important for patients / consumers are obvious factors such as shape and color. If there are differences or defects such as deformities, color changes or air pockets in the tablet, they are recognized as defective and are not taken. The oblong tabs tested here, made of pressed microcrystalline cellulose, lubricated with talc and coated with egg-oxide / titanium dioxide, naturally do not contain any active ingredients in the test series. The aim of this study is to find out how these tablets can most effectively be returned to a form to recycle the constituents of the tablet.

Preparation and test requirements

For grinding and de-agglomerating the oblong tablets, a CONIKA 6 conical sieve mill was used with round sieves in the size of 5 mm, 2.5 mm, 1 mm and 0.6 mm. The motor power of this model is 4 kW. Although the rotor speed of the CONIKA can be variably adjusted to keep the variance of the test low and to make the results as easy as possible to interpret, a fixed rotor speed of 2,000 revolutions per minute was set. The rotor-to-screen distance is also adjustable, but was set to 1 mm.
The test procedure was always identical: The funnel of the machine was filled with 5 kg of the oblong tablets before the machine was started. The product was collected in a sack attached to the machine and the particle size distribution was measured immediately after each test run.

5 mm

2.5 mm

1 mm

0.6 mm

The test material is micro-crystalline cellulosic tablets pressed in oblong tablet form with a width of 15 mm, a total height of 5 mm and a depth of 5 mm. Due to the iron oxide and titanium dioxide coating, the tablets appear in a yellowish to beige color.

If the tablets are broken, you can see the white microcrystalline cellulose on the inside and the corresponding yellow / beige coating on the edge.

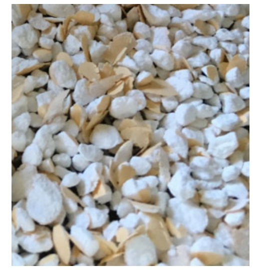
In order to determine the product particle size and thus the influence of the various round sieve hole sizes on the crushing / de-agglomeration process, 7 test series were set up and carried out. Each test series started with the raw material, the tablets in their original form. In each subsequent step, the product of the previous process step was used.

Used sieves with hole sizes in mm

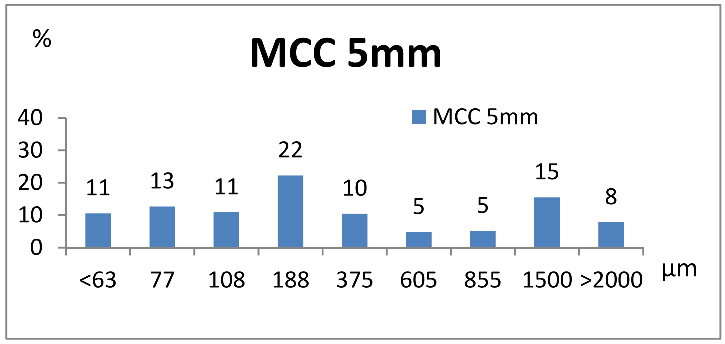
test series	process step 1	process step 2	process step 3	process step 4
1.	5	2.5	1	0.6
2.	5	1	0.6	
3.	5	0.6		
4.	2.5	1	0.6	
5.	2.5	0.6		
6.	1	0.6		
7.	0.6			

For the evaluation of the test data, the results with the same sieve hole size are directly compared with each other, taking into account the task size. This works for every sieve size except the sieve with the largest hole diameter (5 mm). Since, due to the design, a certain amount of product remains stuck in the measuring sieves, when measuring the particle size distribution the percentage valuses measured less than 1 are always evaluated as zero. When creating the evaluation diagrams, the representation of the percent did not take in to account the decimal place, which may result in the sum of all percent not being 100.

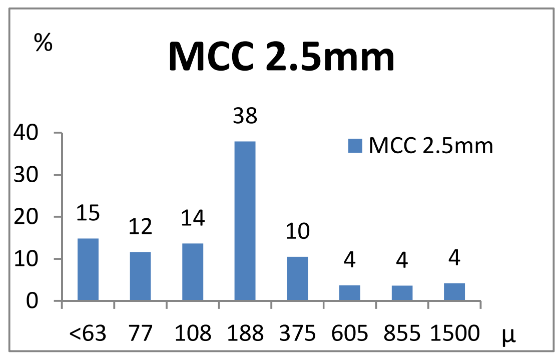
Test procedure and evaluation

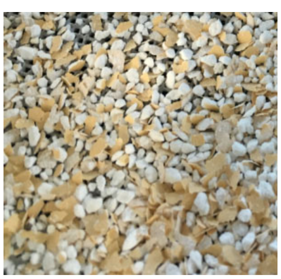


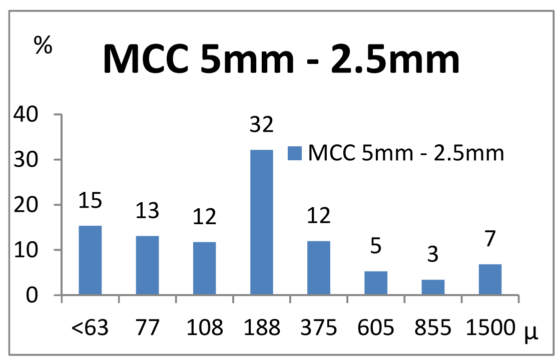
When using the 5 mm sieve, the tablets break up but do not yet completely separate the interior of the tablet from the coating. This results in an "opened product" of microcrystalline cellulose, which is still firmly attached to the coating of the tablets. To completely break down the 5 kg tablets so that no remaining raw material remains in the sieve, the CONIKA takes 1:24 minutes. As can be seen in the lower graph, particles of very different sizes are created. The highest percentage of the particle size distribution is in the range of 188 µm (22%). The large sieve hole size in relation to the other sieves shows directly that approx. 23% of the product is still considerably larger than 1 mm.



When using the 2.5 mm sieve, the microcrystalline cellulose separates from the coating. Large coating flakes emerge and the pressed microcrystalline cellulose takes on a lens shape. In addition, a significantly larger amount of microcrystalline cellulose and coating fines are produced. 7.2 g of the raw material remained in the screen at the end of the process. As can be seen in the graph, there is no product more than 2 mm in size. The portion in the range of 1.5 mm achieved in the direct processing with the 2.5 mm sieve was added in the material milled with the 5 mm sieve and reworking with the 2.5 mm sieve. The largest increase in the percentage of size was 188 microns. For this process step, the CONIKA 6 took 18 seconds.



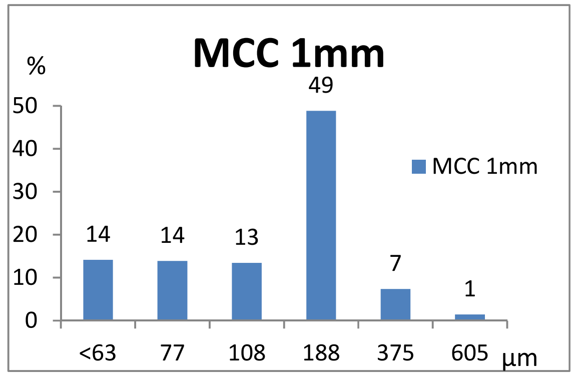




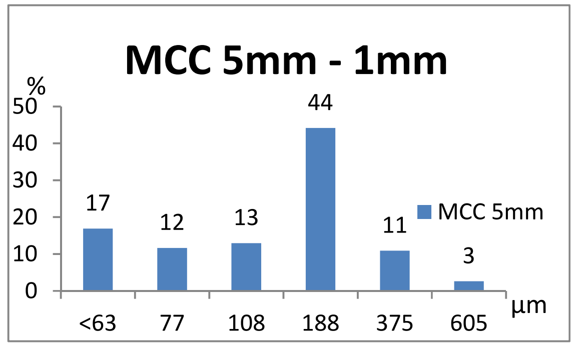
If one compares the data from the process steps between direct milling with the 2.5 mm sieve to the 2 process steps with first only a 5 mm sieve followed by the 2.5 mm sieve, then one sees that with direct grinding the large portion is smaller and that portion appears directly in the peak of 188 microns.

When using the 1 mm sieve, three different tests were performed. In the first test, the raw material without pre-treatment was crushed directly with the 1 mm sieve. In the 2nd test, the raw material was pretreated with the 5 mm sieve. In the third test, the oblong tray was prepared with the 2.5 mm sieve.

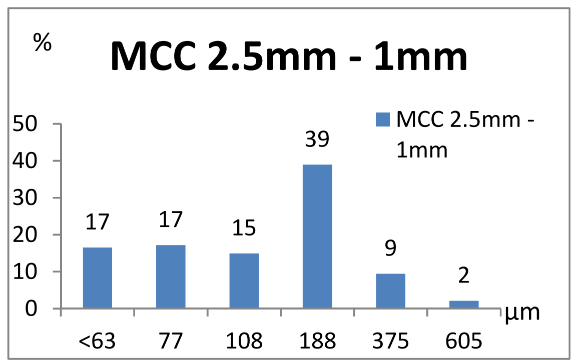
It was interesting to see that during the pre-processing of the oblong tablets with the 5 mm sieve (process duration 1:24 min.) and the 2.5 mm sieve (process time: 2:00 min.), the next process step with the 1 mm sieve took 40 seconds in both cases. When directly grinding the tablets with the 1 mm sieve, the process took 2:15 minutes. The product residue, which remains of the 5 kg of starting material at the end of the process in the sieve, was about 60 g in all size variations.

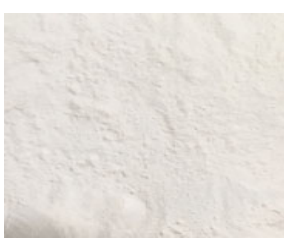


When considering the particle size distribution, there are clear differences in the use of different sieve sizes.
The direct use of a 1 mm sieve, without milling the product with a different sieve size, shows that in comparison with the other test series, the smallest coarse fraction occurs in the product produced.
The primary peak is 49% and the total fraction, which is larger than 188 µm, is only 8% in total. The values smaller than 188 µm are thus <63 µm, 77 µm and 108 µm and all are approximately equal distributions.



The pre-processing with a 5 mm sieve and subsequently with the 1 mm sieve shows a higher very fine proportion with 17% <63 µm (increment = + 3%), but the primary peak drops to 44% (loss = -5 %) and the proportion greater than 188 µm increases overall by 6%.

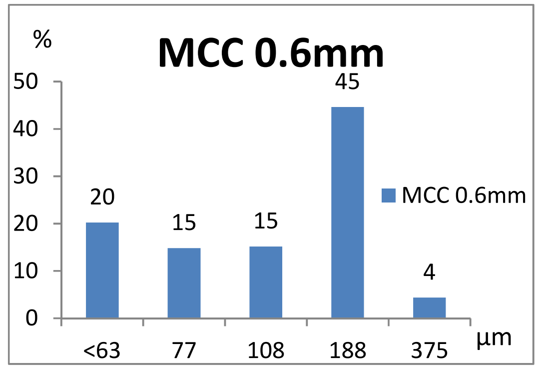


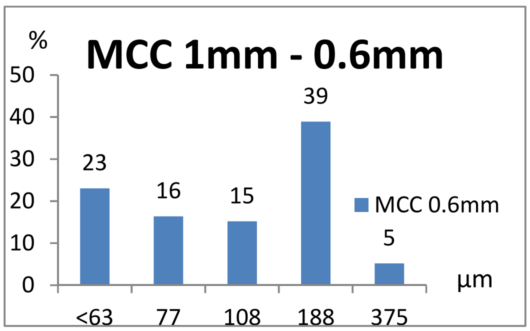


Although the particle size distribution of the product with preparation of the raw material with the 2.5 mm sieve drops to 39% (compared to the 10% particle size distribution without preprocessing), the total fraction less than 188 µm significantly decreases 8% too. The proportion greater than 188 microns increases by a manageable 3%. This development shows the clear influence of the sieve size on the particle size distribution.

When using the 0.6 mm sieve, it is important to note which corresponding sieve size was used for milling the tablets with the CONIKA 6. The results of processing the tablets without a pre-process are still excellent. As usual, the primary peak is 188 µm, with the proportion of the largest particles at a size of 375 µm limited to a small value of 4%. The proportion of particle size distribution smaller than 63 microns is quite large at 20%. The other values, less than 188µm, are well represented at 15% each.

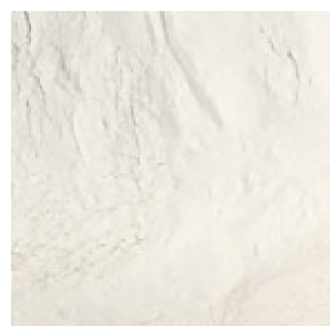
Of course, it takes quite a while for the raw material to become small enough. For the 5 kg test 2:11 minutes was needed. One potential disadvantage of this process may be the temperature that arises during the process. Due to the narrow meshes, a lot of frictional heat is generated (measured at 40.9 ° C) and could have an effect on the products (especially for very sensitive tablet materials). Also, the largest remaining portion which remained in the sieve was measured during this test (remaining in sieve = 300 g).

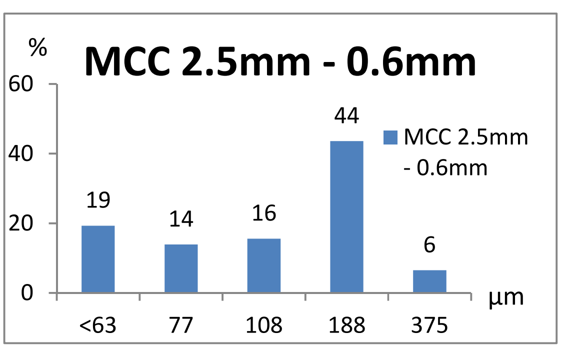


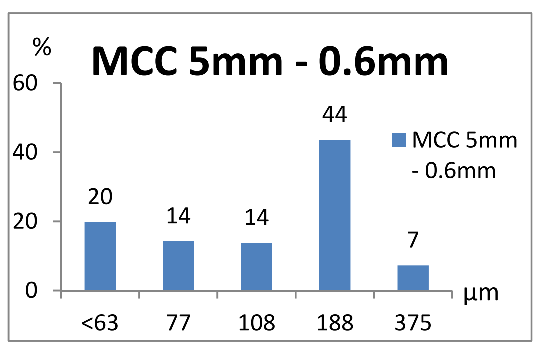


If the product was previously processed with the 1 mm sieve, you will also get a very good result. In the pre-shredding of the base material, it takes approximately the same length of time as when reducing the product size with the 0.6 mm, and an additional 40 seconds for the de-agglomeration of the 1 mm screen product with the 0.6 mm sieve. However, one avoids the problem of overheating the material (T = 29 ° C after the size reduction with 0.6 mm sieve). In addition, fine particles in the range <63 µm are recovered at 3% and 1% is in the range 77 µm, whereas the primary peak reduces to 39% and one percentage point is added to the largest measured diameter at 375 µm. In this variant, only about 60 g of the residual product were in the working chamber.

In the pre-processing of the oblong tablets with the 5 mm sieve or the 2.5 mm sieve, it has been found that for the final product - the product after processing with the 5 mm sieve or the 2.5 mm sieve and the following process with the 1 mm sieve - there is little difference in the particle size distribution. The primary peak is 44% for both. The coarse fraction of 375 microns, making it 6% to 7%, is quite high compared to the previously described processes.







Conclusion

Fundamentally, as it is often the case in science and technology, there is no patent recipe with which all requirements can be solved in just one single process and one single tool. However, it has become clear that careful use of the sieves can influence the process time, the particle size distribution, the temperature and even the shape of the microcrystalline cellulose and the coating of the oblong tray.

Depending on the requirements, it may be useful to think about the right choice of sieves in order to produce the optimal product: If the desire is to produce a product with a maximum of particles with a particle size of <63 µm, it may be accurate to first pre-treat the raw material with a 2.5 mm sieve and then finish it with a 0.6 mm sieve.

If it is desired to realize everything in one process step without the temperature playing a role, it may be right to work directly with a 0.6 mm sieve with just one single process step.

Or should the particle size distribution resemble a Gaussian curve and the desired maximum proportion be in the range of 188 µm, then the first process step could be the use of a 5 mm sieve and as a second step the use of the 1 mm sieve.

At last, the process decides which sieve is needed. Great that there is a selection!