Grain by grain: How particle composition influences the workability of scratch plaster

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The properties of wall plasters, scratch plasters, and other building materials are strongly influenced by the size and shape of the particles used. Measurements of size and shape as well as rheological tests help to identify differences between samples.

Choosing the right wall or scratch plaster is important for a successful result. In addition to the aesthetic aspects, the processing properties also play an important role. In order to develop and select a scratch plaster with optimum properties, e.g., a detailed understanding of the internal structure is necessary.

Particle size and particle shape analyses as well as rheological tests provide valuable insights in this regard and allow researchers to decipher the relationships between the material composition (including the aggregates) and the processing behaviour.

The flow behaviour of a scratch plaster is the result of a complex interplay of particle size and shape, and the properties of the surrounding matrix. For example, large, spherical particles in combination with small, platelet-shaped particles can lead to a good compromise between flowability and strength. By specifically adapting the particle properties, the plaster can be adjusted so that it can be pumped or distributed easily and has a time to level out but not sag down. Mechanical properties such as strength, water repellence, appearance, and surface texture can also be influenced.

In the following, two different scratch plaster samples *(Figure 1)* were examined and compared using dynamic image analysis and rheometry. The resulting load vs. indentation depth curves provide data specific to the mechanical nature of the material under examination.

Figure 1: Scratch plaster samples A (left, particle size 1 mm), and B (right, particle size 2 mm)

Measurement methods

The Litesizer DIA 500 measuring device *(see Figure 2)* is a single-camera, dual-lens device with automatic lens switching and an option for automatic data merging. Switching between the dispersion units for wet and dry measurements is performed routinely within seconds, without tools or cumbersome handling of tubing.

The measuring range of the zoom lens is between 0.8 µm and 300 µm, while the measuring range of the standard lens is between 10 µm and 16 mm. The combination of high magnification and small pixel size determines the detectable size range and is the key to analysing fine particles or small superficial features on larger particles in detail.

An air-bearing-based Modular Compact Rheometer (MCR) from Anton Paar equipped with a BMC90 (Building Material Cell) was used for the rheological tests.

Figure 2: The dispersion unit of Litesizer DIA 500 can be replaced with a single movement thanks to the Quick-Click system. Left: Liquid flow dispersion unit (wet dispersion); centre: Free-fall dispersing unit (gravity dispersion); Right: Dry-jet dispersing unit (compressed air dispersion).

The BMC90 is particularly suitable for measuring samples with larger particles due to the two-blade stirrer and the built-in cage. The scratch plasters used here with 1 mm or 2 mm particles would not be measurable with regular measuring geometries such as cylinders or cone-plates.

Experimental conditions

Samples A and B were measured wet-dispersed with Litesizer DIA 500 and the liquid flow module from Anton Paar (measuring time: 20 sec, pump, stirrer: medium, no ultrasound). For this report, the parameters xA (area-equivalent diameter) were used for the consideration of the size and the parameter shape factor.

Both samples were also measured rheologically. The tests were flow and viscosity curves in rotation to measure the shear rate-dependent viscosity and the yield point of the two samples.

The viscosity curves were generated using a logarithmic shear rate ramp from 0.01 1/s to 100 1/s. The flow curves were then measured with a linear shear stress ramp from 1 Pa to 1,500 Pa.

Results

Particle sizes and shape distribution

Sample A and sample B show clear differences in size distribution, as shown in *Figure 3*. Sample A has a Q390 of 1.02 mm, while sample B is 1.83 mm. A closer look at the fine and coarse fractions reveals the difference even more clearly: 48% of the particles in sample B are larger than one millimetre, while in sample A, 93% are smaller than one millimetre. The proportion of fine particles (less than 0.3 mm) is equally high in both samples. There are also no significant differences in the distribution of shapes. The data are also shown in *Table 1* for the purpose of clarity.

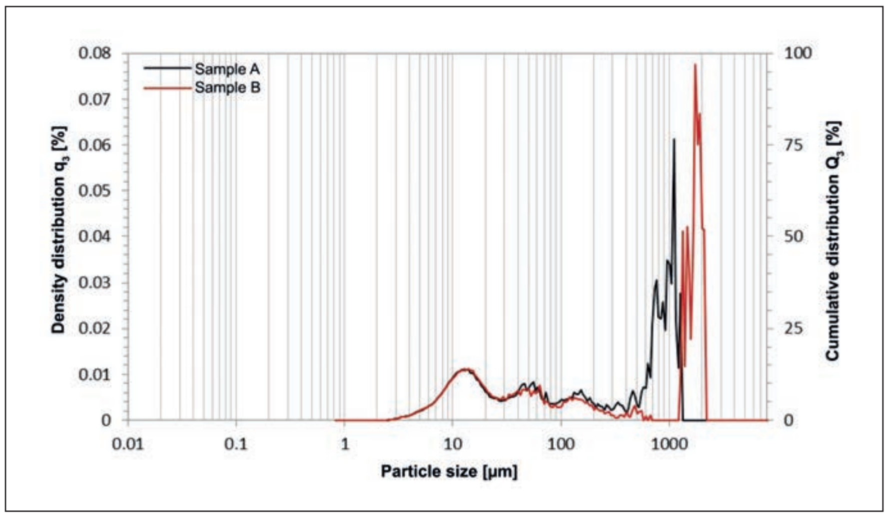

Figure 3: Volume-weighted particle size distribution xA for

Table 1: Comparative data of the two samples in terms of particle size distribution.

Related to xA	Sample A	Sample B
Q3 50 / mm	0.19	0.37
Q3 90 / mm	1.02	1.83
<1.0 mm / %	93	52
1.0-2.0 mm / %	7	48
>2.0 mm / %	0	0
Form factor Q3 50 / mm	0.77	0.79

Real images of the two samples in real size ratio:

1 mm sample

2 mm sample

Viscosity curves

The samples showed a shear-thinning viscosity with increasing shear rate *(see Figure 4)*.

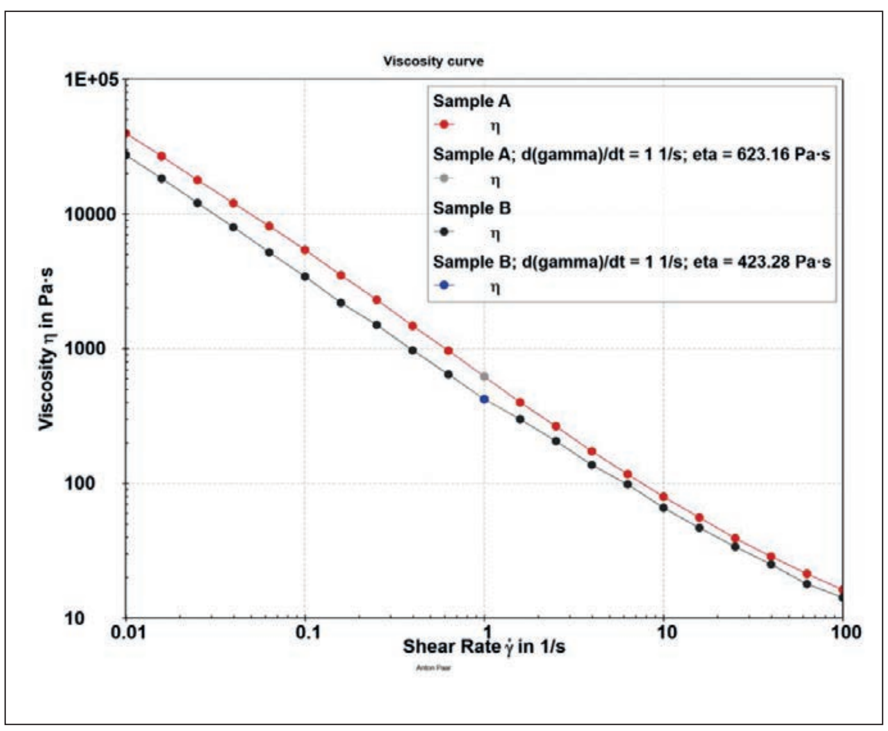

Figure 4: Viscosity curves of the two samples.

Interestingly, sample A with maximum 1 mm large particles showed higher viscosities than sample B with a maximum of 2 mm large particles. As an exemplary result, the viscosities at 1 1/s were evaluated.

Sample 1 shows a viscosity of 623 Pas, whereas sample 2 only measures 423 Pas.

Flow curves

The measured flow curves show that the sample with higher viscosities also has a higher yield point *(see Figure 5)*. Sample A shows a yield point in the gamma-tau diagram of approx. 600 Pa, while sample B already starts to flow at 413 Pa.

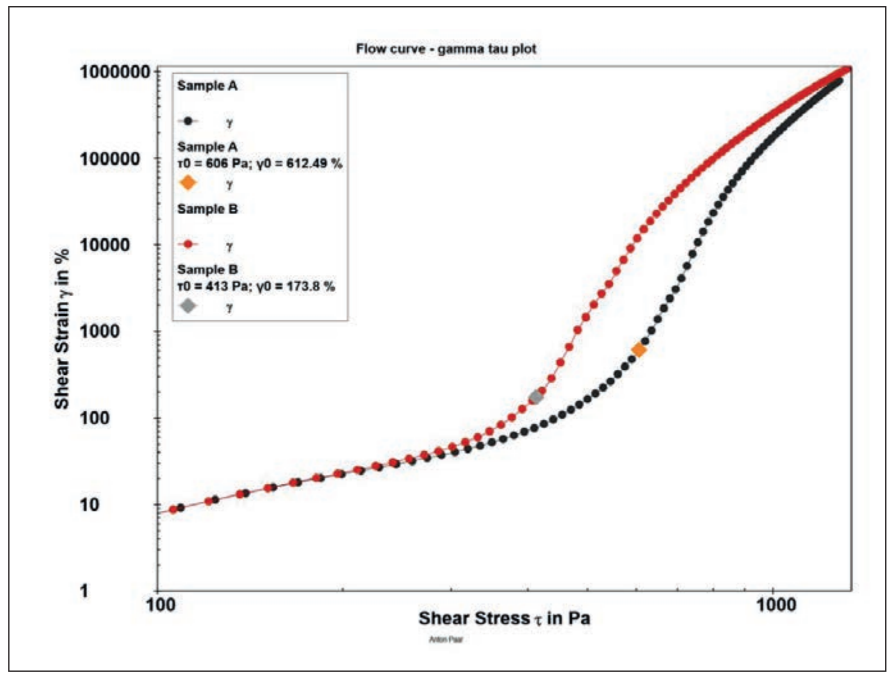

Figure 5: Yield point determination in a gamma-tau plot.

Interpretation and conclusion

Particle size, distribution, and shape have a decisive influence on the rheological properties of scratch plasters. The precise measurement of samples by means of rheological and particle-determining tests results in advantages in the improvement of existing products, research for new formulations, and the guarantee of consistent quality of standard products.

As the particle size measurements show, sample A has a has a slightly more homogeneous particle size distribution, which leads to better interlocking of the particles with each other. This better interlocking can be demonstrated rheologically by the higher viscosity and yield point.

As no differences were measurable in the shape determination, the differences in the rheological properties can be attributed exclusively to the particle size distribution. The viscosity curves of the two samples show a very similar course, which is desirable to ensure a consistent application even with significant changes in particle size and distribution.

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