Sintered Metal Filter: Real Test Dust Filtration

cvt engineering

The structures are generic, built from assumed powder sizes. The numbers demonstrate the method, not product data of any manufacturer.

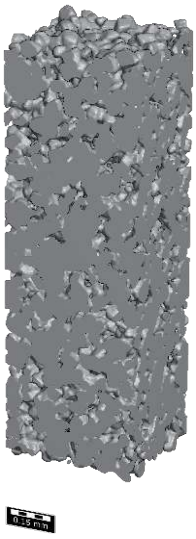
1. Question and setup

How does a sintered metal filter capture the dust of a given size distribution? We simulate three filter grades, all with a core thickness of about 1.4 mm in the flow direction, at a face velocity of 5 cm/s in air, with two test dusts of lognormal size distribution (geometric standard deviation 2 by mass, mass-median 3 µm and 25 µm), each injected with its full size distribution (20 log-spaced size classes from 0.5 to 80 µm, 2500 tracked particles per class). The report shows the filtration efficiency and where the captured dust mass sits in the filter.

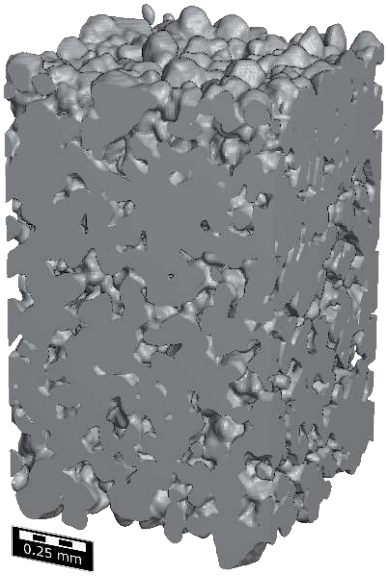
2. The three grades



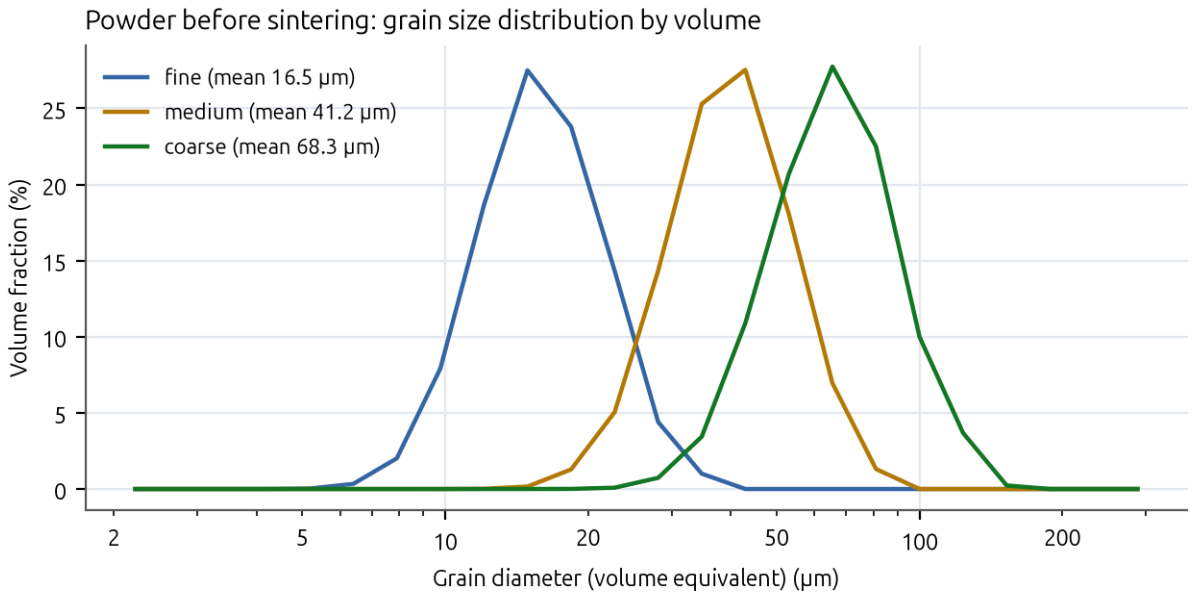
Fine grade, 0.67 µm/px



Medium grade, 0.67 µm/px



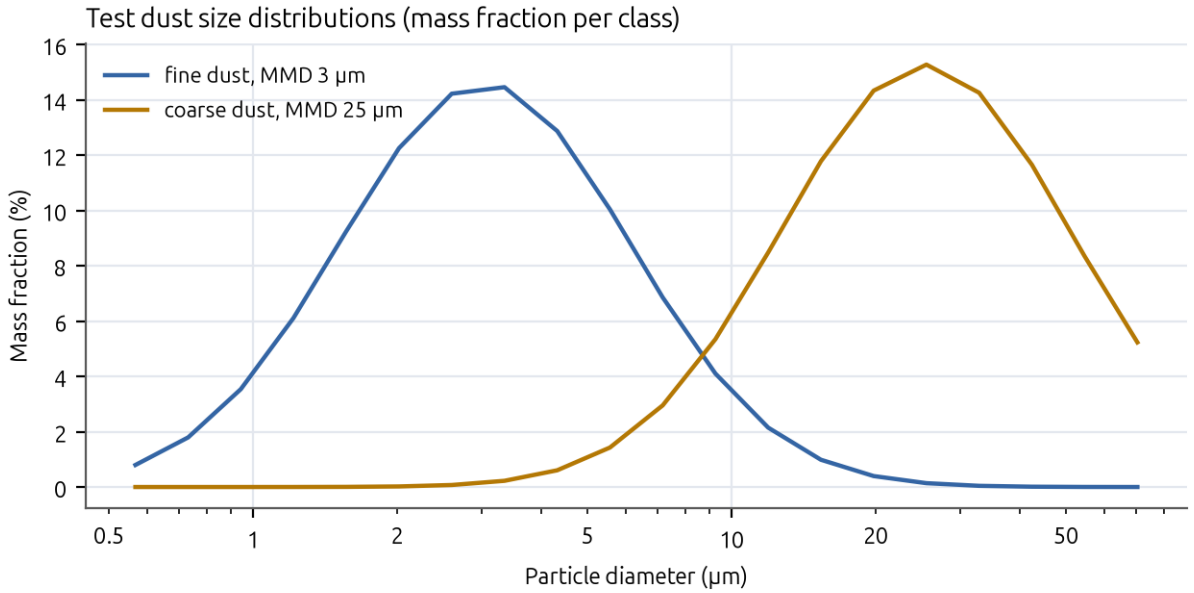
Coarse grade, 0.67 µm/px



Source: `models/report_data_1500/GrainSizeDistributions.gdr` (GeoDict:CustomAnalysis)

The nominal grade sizes 20 / 50 / 100 µm are the long axis of the grain's enclosing ellipsoid; the plot shows the volume-equivalent diameter of the grains GeoDict actually created, before sintering.

3. The test dusts



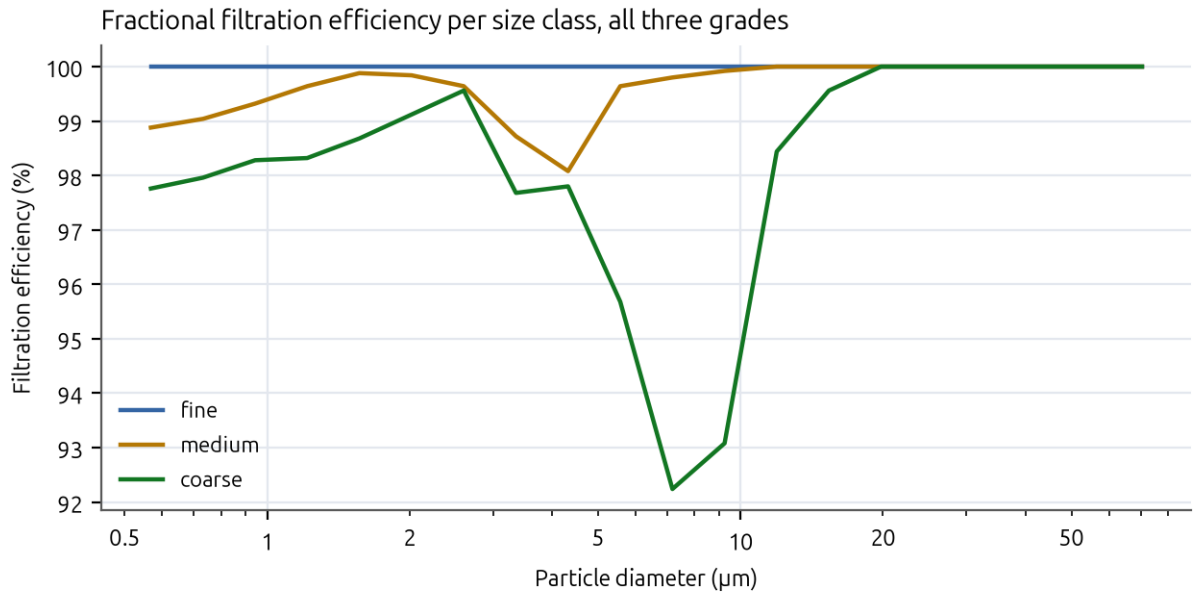
Source: `models/report_data_1500/DustDistributions.gdr` (GeoDict:CustomAnalysis)

Both dusts are lognormal (geometric standard deviation 2 by mass), truncated at 0.5 to 80 µm. The fine dust has a mass-median diameter of 3 µm, the coarse dust 25 µm.

4. Filtration efficiency

Grade	Count efficiency, fine dust (%)	Mass efficiency, fine dust (%)	Count efficiency, coarse dust (%)	Mass efficiency, coarse dust (%)
fine	100.0	100.0	100.0	100.0
medium	99.31	99.36	99.48	99.97
coarse	98.24	97.58	96.65	99.14

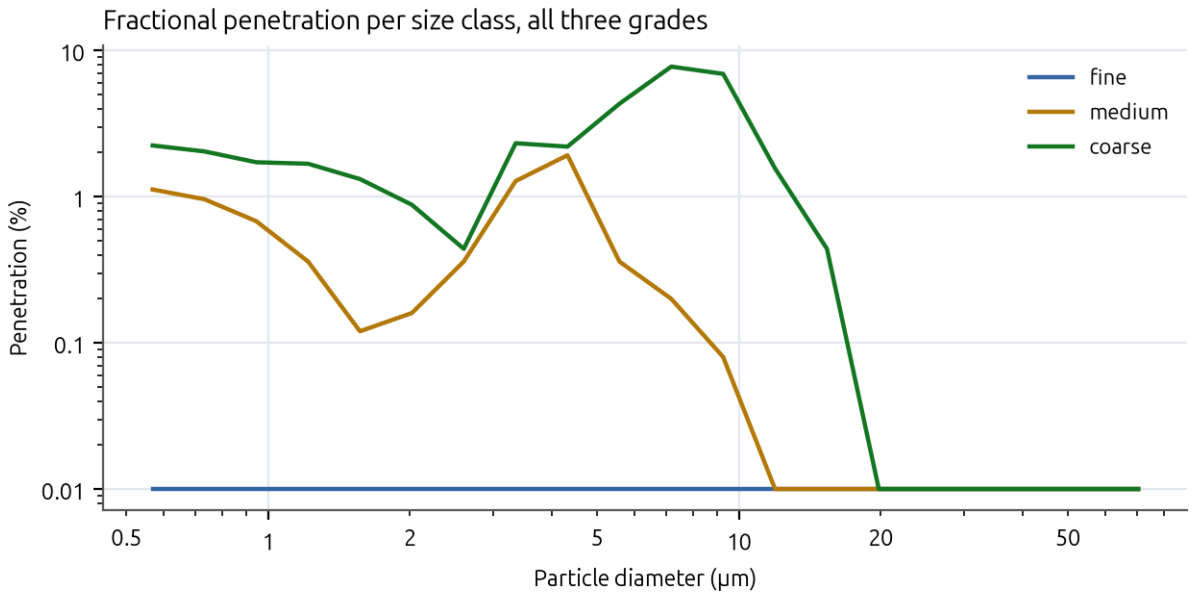
Source: `models/report_data_1500/GradeComparison.gdr` (GeoDict:CustomAnalysis)



Source: `models/report_data_1500/FractionalEfficiency.gdr` (GeoDict:CustomAnalysis)

Per-class efficiency does not depend on the dust: each class is a fixed set of particles of one size in the same clean flow, and the dust only determines the share of each class, so this single set of curves applies to both test dusts.

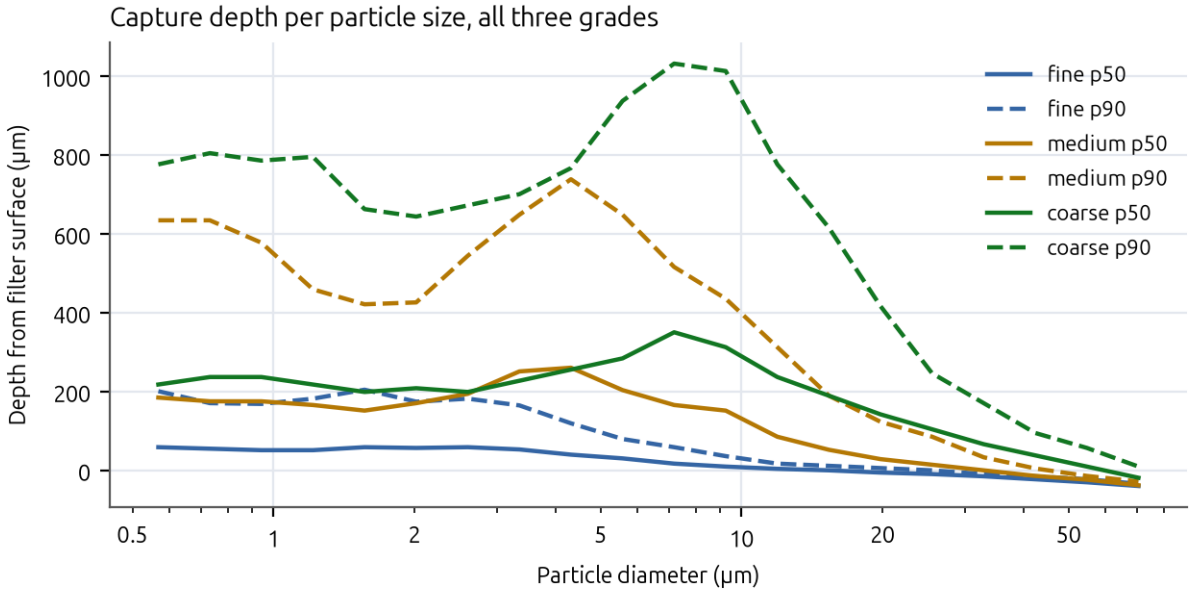
The efficiency stays close to 100 % over the whole size range; the next plot is a close-up of that region, 100 % minus fractional efficiency on a log axis, with classes with no detected penetration at the 0.01 % floor.



Source: `models/report_data_1500/FractionalPenetration.gdr` (GeoDict:CustomAnalysis)

5. Depth penetration

Which particle sizes penetrate how deep: for each size class, the depth at which 50 % (p50) and 90 % (p90) of the class's own caught particles have been captured, measured from the filter surface (the Z layer where the solid volume fraction first reaches half of its bulk value in embedded_merged.gdt); capture on protruding grains above the surface is negative. No dust weighting: each size class on its own.



Source: `models/report_data_1500/DepthPerSizeAll.gdr` (GeoDict:CustomAnalysis)

Class diameter (µm)	fine p50 (µm)	fine p90 (µm)	medium p50 (µm)	medium p90 (µm)	coarse p50 (µm)	coarse p90 (µm)
0.943	51.1	168.5	175.1	577.4	236.7	785.7
5.571	30.3	79.5	203.5	648.4	284.0	937.1
19.813	−5.7	5.7	28.4	123.1	142.0	416.5

Source: `models/report_data_1500/DepthPerSizeAll.gdr` (GeoDict:CustomAnalysis)

p50 / p90 per grade at the three key size classes (nearest 1, 5 and 20 µm).

6. Captured dust

The images show the caught particles of each test dust in its own size mix, the structure cut in half, flow from the top. All images of the report are at the same scale of 0.67 µm/px, so grain sizes can be compared across grades and dusts; compare fine and coarse dust within a column.



Fine grade, fine dust, 0.67 µm/px



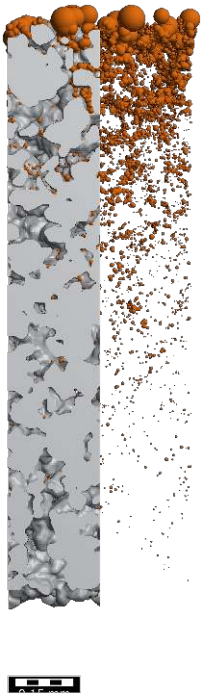
Medium grade, fine dust, 0.67 µm/px



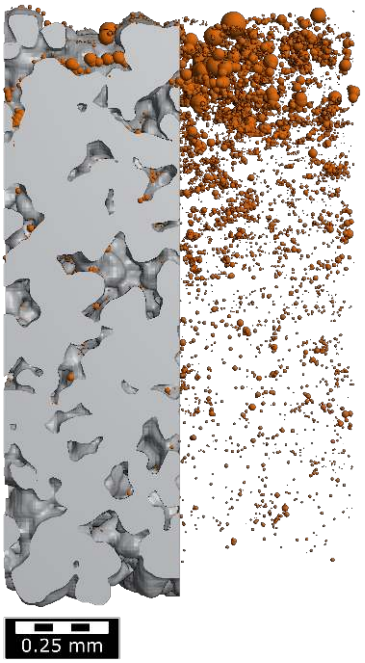
Coarse grade, fine dust, 0.67 µm/px



Fine grade, coarse dust, 0.67 µm/px



Medium grade, coarse dust, 0.67 µm/px



Coarse grade, coarse dust, 0.67 µm/px

7. Findings

1. All three grades filter both dusts with a mass efficiency of at least 97.58 % at 5 cm/s. The fine grade reaches 100.0 % on both dusts and captures 100 % of every size class.
2. Grade separation is largest on the fine dust: 97.58 % (coarse grade) versus 100.0 % (fine grade), versus 99.14 % to 100.0 % for coarse dust.
3. In the medium and coarse grades the class that penetrates deepest is the class with the lowest per-class efficiency: 4.32 µm in the medium (p50 260.3 µm from the surface) and 7.18 µm in the coarse grade (350.2 µm). These particles are too small for inertial or interception capture at 5 cm/s and too large for Brownian diffusion to be significant; the coarser the grade, the larger this most penetrating size and the deeper it goes. The fine grade captures every class with 100 % efficiency, and its deepest penetration (p50 58.7 µm) is at the smallest size classes.
4. The largest particles are caught on the grains protruding above the surface: at the largest class (70.5 µm), p50 is 18.9 to 39.8 µm above the surface in all three grades, and the finer the grade, the more size classes are caught at or above the surface.