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The Influence of modern diesel technology on the size of aggregate particles

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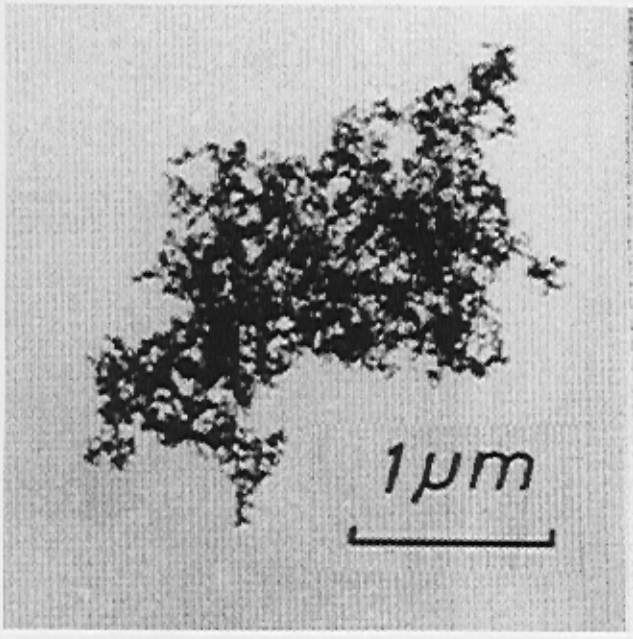
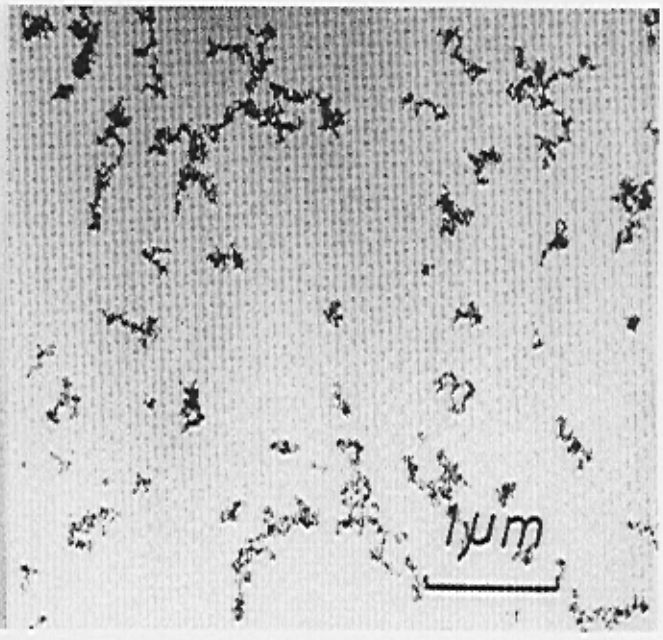
zur Fragestellung inwieweit moderne Dieseltechnologien die Partikel-Größenverteilung beeinflußen
(The influence of modern diesel technology on the size of aggregate particles)

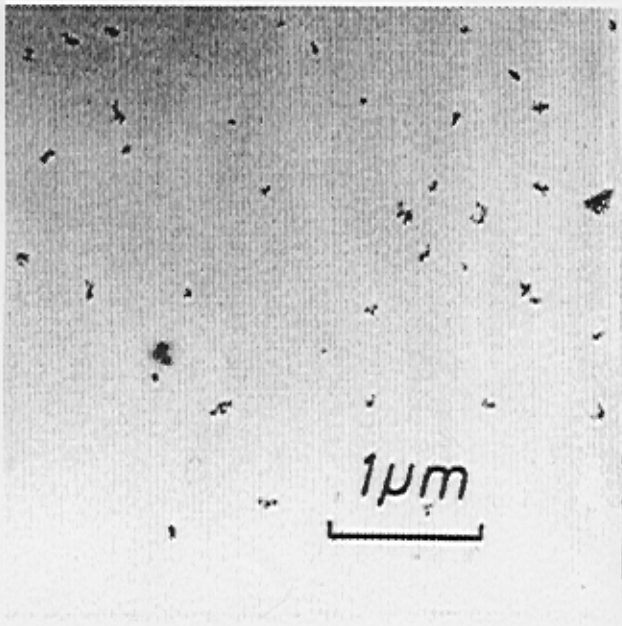
Twenty years ago the maximum of the frequency distribution of diesel particulates from prechamber engines was at 120 to 150 nm measured with cascade impactors (Berner), while lead particles from gasoline engines without catatylic converters had their maxima about 20 to 40 nm (SAE 790421). The size were additionally measured with electronic microscopes, see figure 1.



Dieselrußaggregatpartikel eines Pkw-Vorkammermotors
Mittlerer Durchmesser 2 µm. Vergrößerung = 12500:1



Dieselrußaggregatpartikel eines Pkw-Vorkammermotors
Mittlerer Durchmesser 0,5 µm. Vergrößerung = 12500: 1



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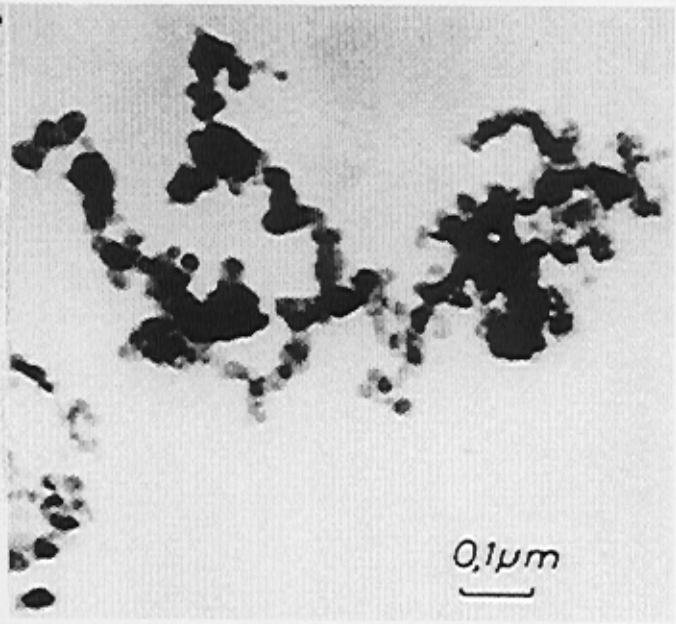

Dieselrußaggregatpartikel eines Pkw-Vorkammermotors
Mittlerer Durchmesser 0,8 µm. Vergrößerung = 80000: 1

Figure 1: Examples of diesel soot aggregate particles of a 2-Liter-passenger car prechamber engine from 1977

The aggregate particles size varied also due to the sampling procedure in the range of 100nm to 2000nm. The highest magnification of 400 000 could be reached with a transmission electronic microscop EM 10 B from Zeiss, see figure 2:

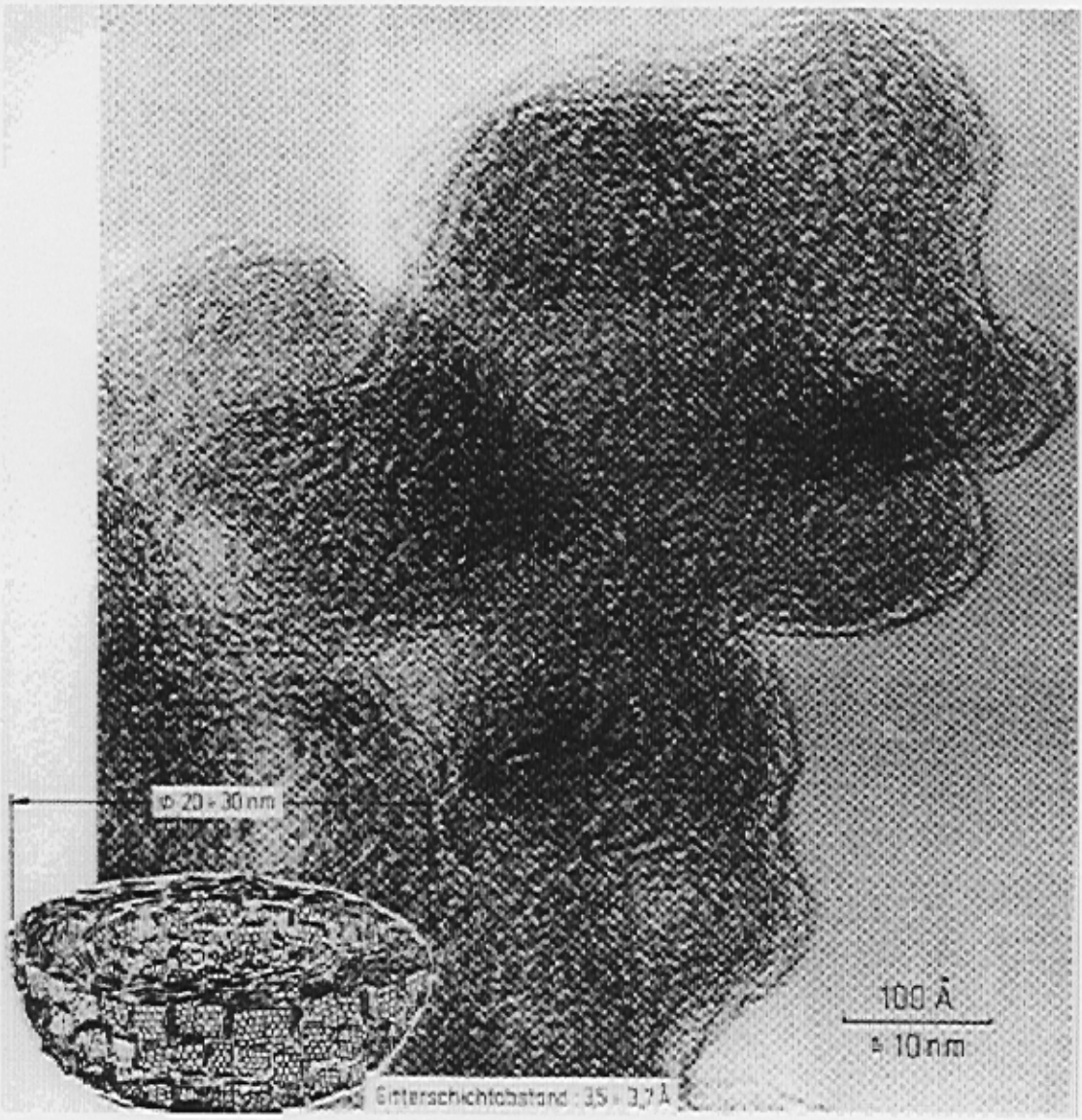

Figure 2: Diesel soot aggregate particle with primary particles in the sizerange 20 to 30 nm of a 2-Liter-passenger car prechamber engine from 1977. Zeiss EM 10 B. Magnification: 400 000:1

It can be seen that the size of the primary particles vary between 20 and 30 nm. For comparison (not shown here) Furnace Soot produced for commercial reason was measured with the same instrument and gave slightly higher diameters for the primary particles 25 to 30 nm. (This furnace soot was treated 30 min. at 2600 degree Celsius). Therefore we do not expect a distinctive shift to smaller primary particles, but this have to be confirmed with the planed investigation.

Two questions have to be answered:
1. Is there a change in particle size of primary particles of different diesel technologies ?
2. Are the aggregate particles of both technologies different in size ?

The first question could only be answered with new electronic microscope investigations which are planed.
The answer for the second question is: No significant change measured with the TSI instrument, described below.

Figure 3 and 4 shows the frequency distribution measured with the scanning mobility sizer model 3934 with a condensation nuclei counter CPC model 3010 from TSI Inc..

The engines tested were
1. 6 cylinder turbocharged swirl chamber 2.5 liter for passenger cars
2. 4 cylinder turbocharged direct injection 2.0 liter for passenger cars and
3. 6 cylinder turbocharged direct injection 3.0 liter for passenger cars with common rail injection

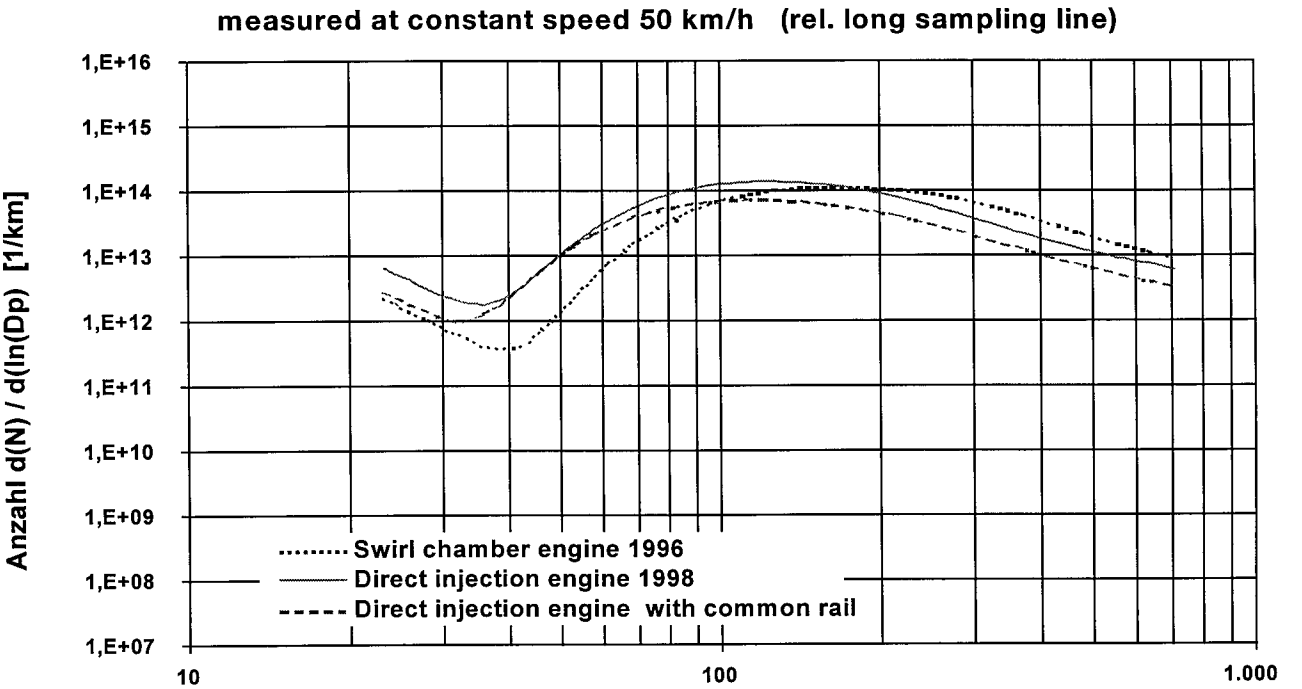

Figure 3: Influence of different engine technologies on the particle-size distribution of passenger cars at 50 km/h

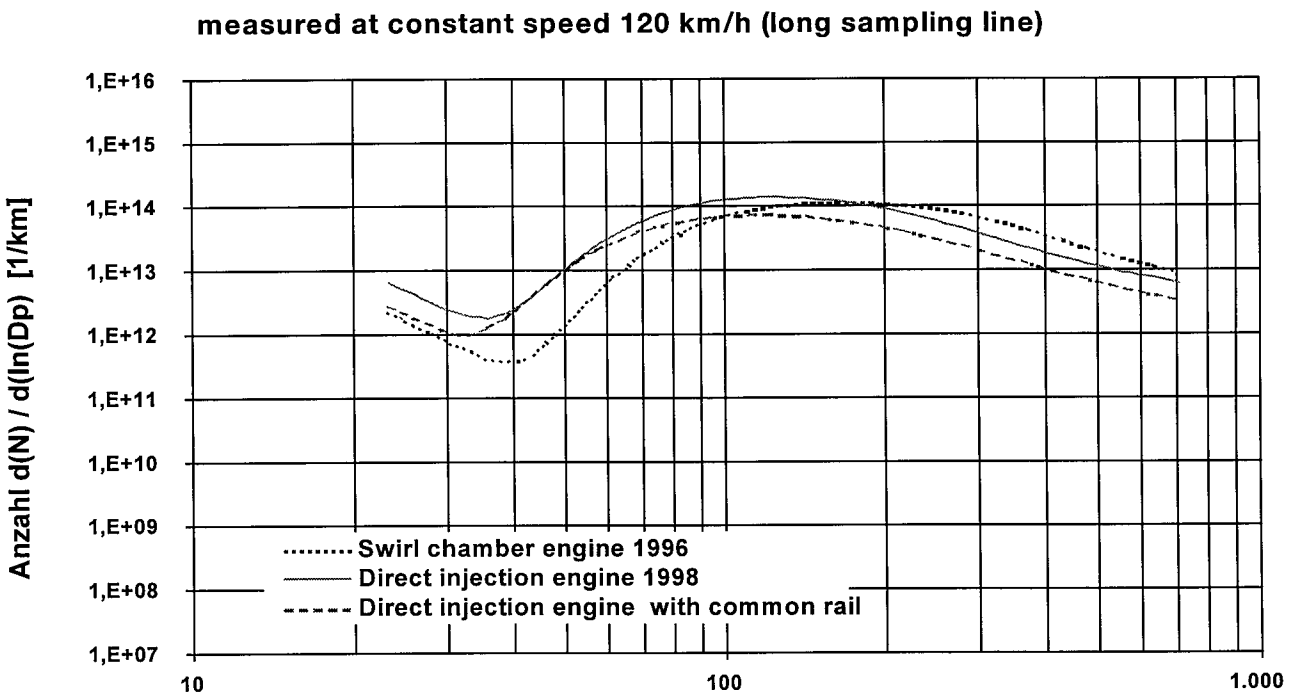

Figure 4: Influence of different engine technologies on the particle-size distribution of passenger cars at 120 km/h

The measurements on the test bench with a dilution tunnel used for certification tests were only possible at constant speeds. Two speeds were chosen 50 km/h and 120 km/h. The fuel was a CEC reference fuel. The tests were conducted with warm engines (oil temperature 80 degree C). Measurements were repeated at least three times.

The results indicate only a slight shift to smaller particles but not as dramatic as in one other publication stated. The results were obtained with a relative to the sampling volume long sampling line. The next measurements will take that into account and will therefore use a shorter sampling line. This change might lead to a more distinct difference.

Dr. Norbert Metz / W-2 / 12.8.1998