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**New Insights into In-Cylinder
Particle Size Distribution Changes
during the Diesel Engine Combustion Process**



***New Insights into In-Cylinder Particle Size
Distribution Changes During the Diesel Engine
Combustion Process***

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Contents



- Description of the engine and the measurement techniques
- In-cylinder soot and gaseous components
- Particle size distribution in the cylinder during fuel injection, combustion and expansion
- Influence of O₂ containing fuel on the particle size distribution in the cylinder
- Conclusions



Engine Data



Engine Displacement:	2151 cm³
Number of Cylinders:	4
Maximum Power:	92 kW at 4200 rpm
Cylinder Bore:	88.0 mm
Cylinder Stroke:	88.4 mm
Compression Ratio:	19.0
Injection System:	Common Rail
Number of Injector Holes:	6
Diameter of Injector Holes:	0.169 mm

Engine Operation Conditions



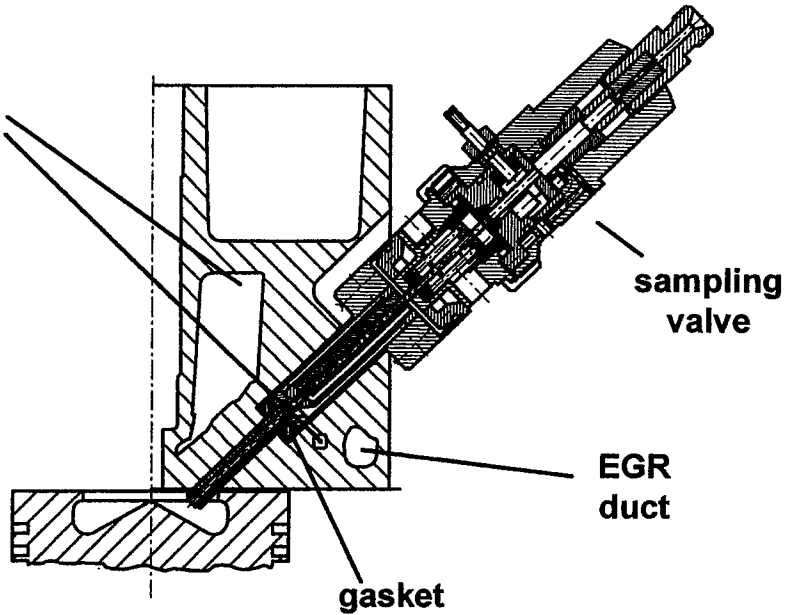
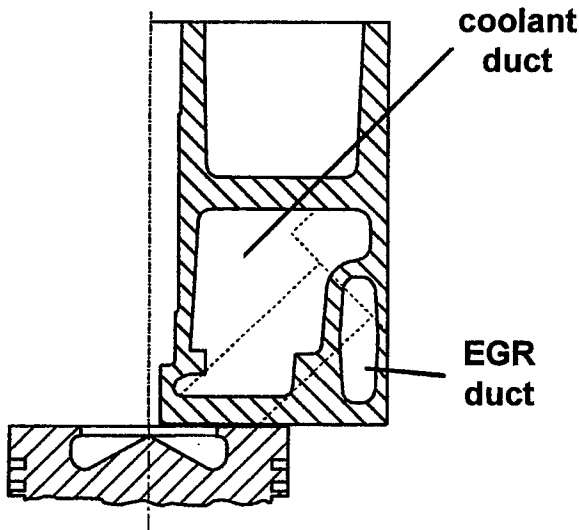
- engine speed: 2000 rpm, bmep: 2 bar (38 ±2% EGR)
- engine speed: 2000 rpm, imep: 10 bar (w/o EGR)

Adaption of the Sampling Valve



original cylinder head shape

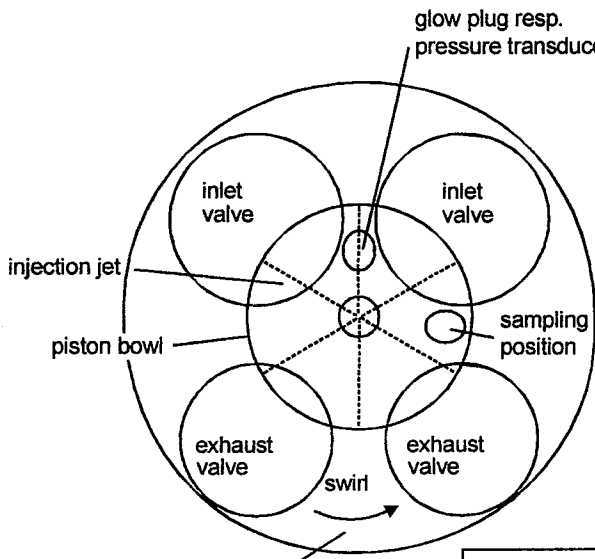
modified cylinder head shape



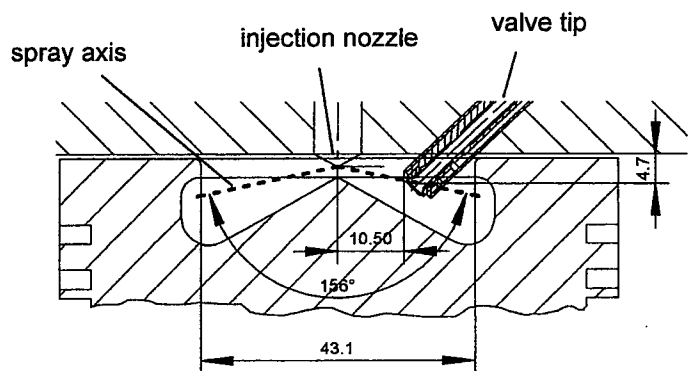
Positions of the Fast Gas Sampling Valve



Top View



Cross Section

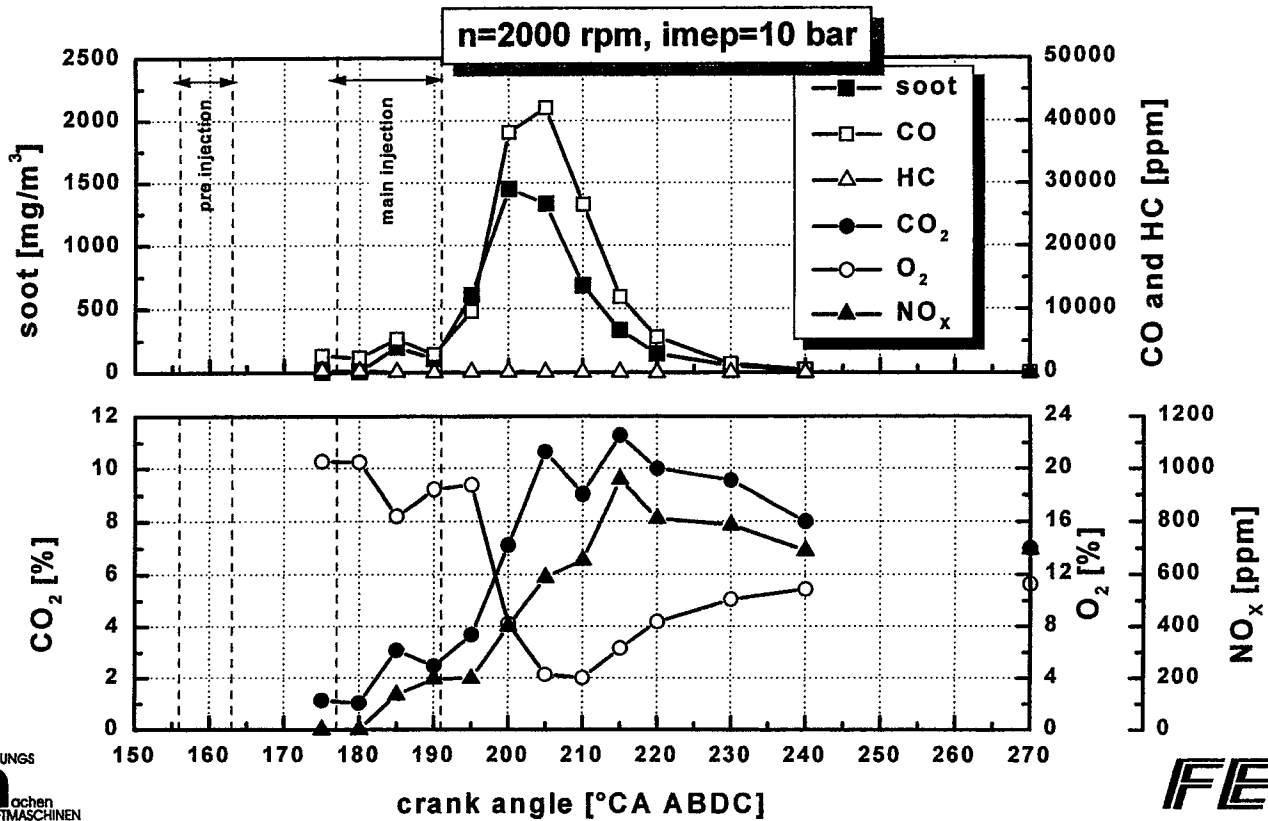


swirl number:

n=2000 rpm, bmep=2 bar:	2.7 (port shutoff)
n=2000 rpm, imep=10 bar	1.8



Results of Fast Gas Sampling In-Cylinder Pollutant Curves (Reference Fuel)

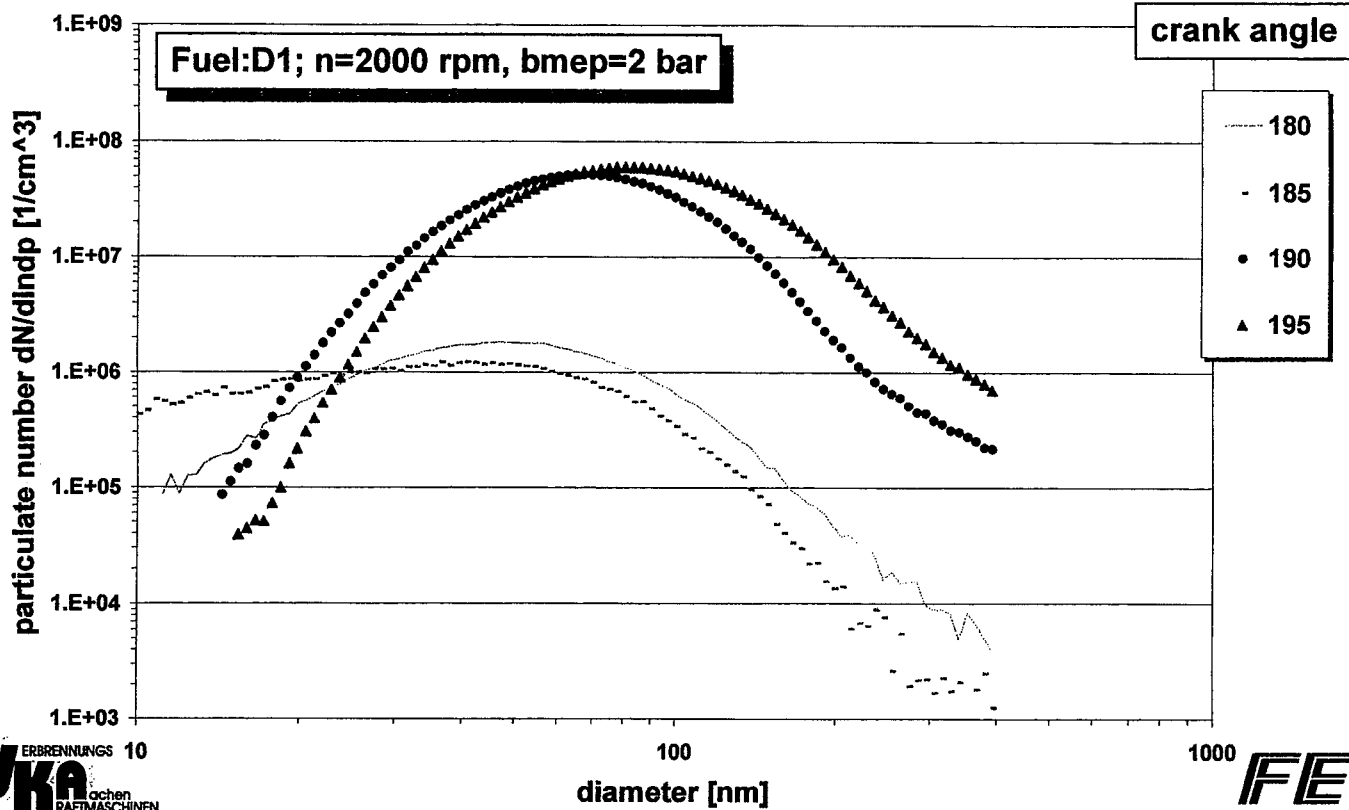


- Particle size distribution in the cylinder during the fuel injection, combustion and expansion



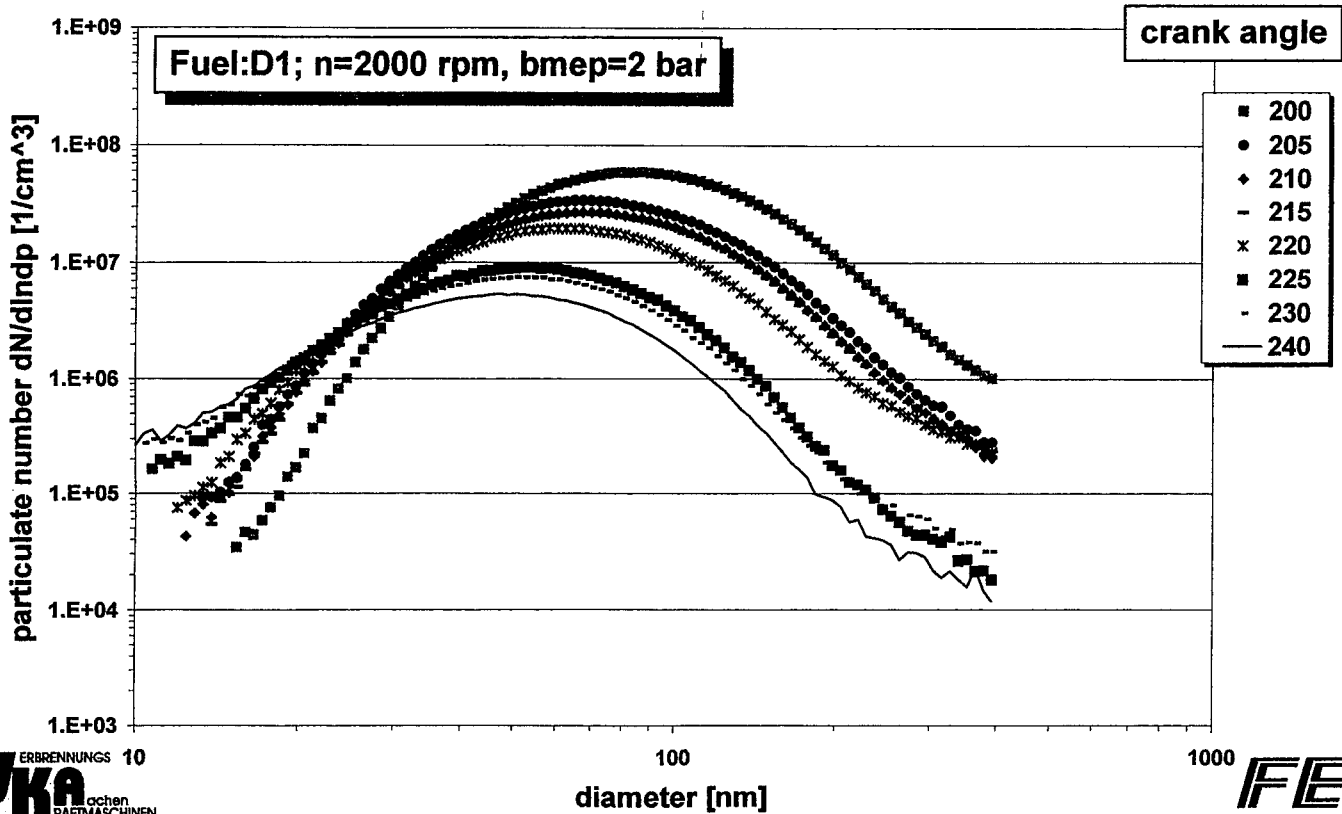
In-Cylinder Particle Size Distributions

Formation of Soot with proceeding Combustion

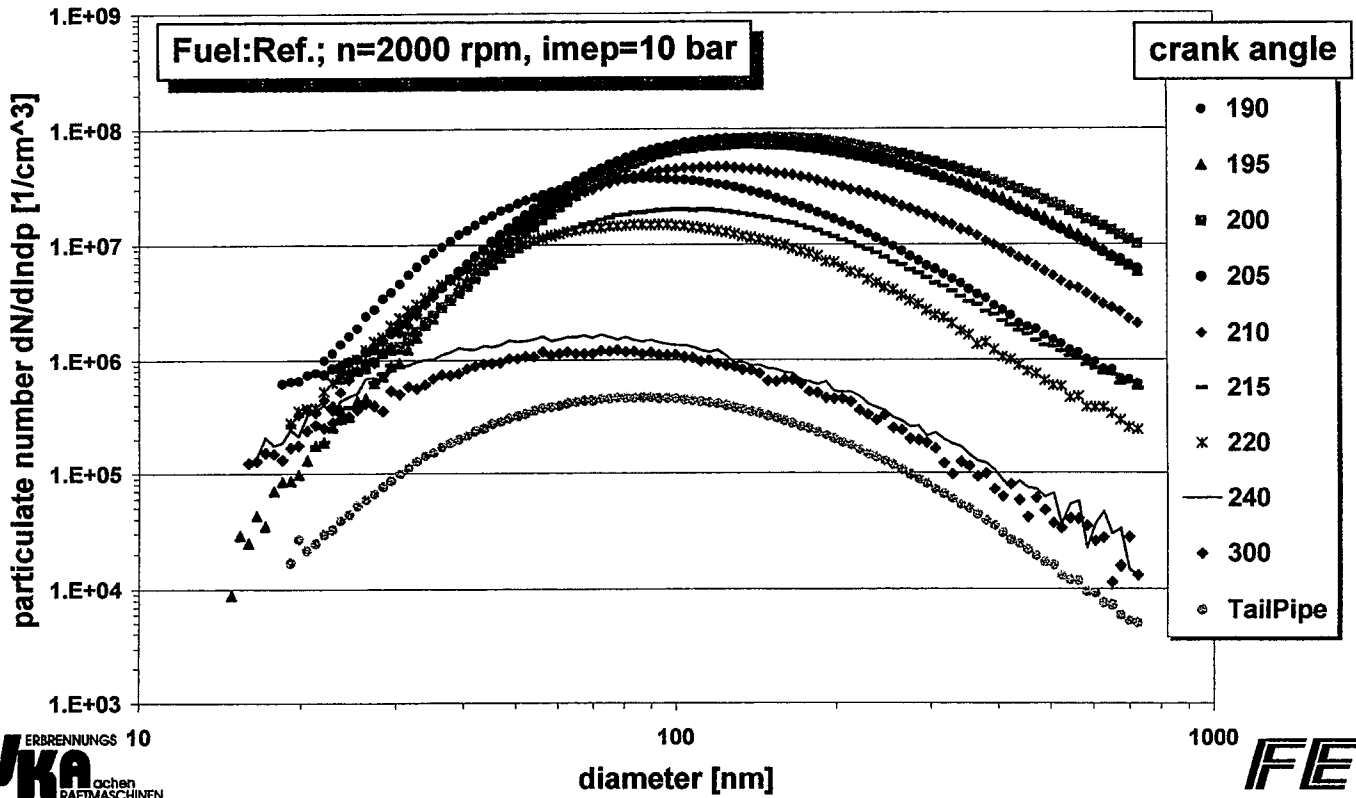


In-Cylinder Particle Size Distributions

Combustion of soot during the Expansion Phase



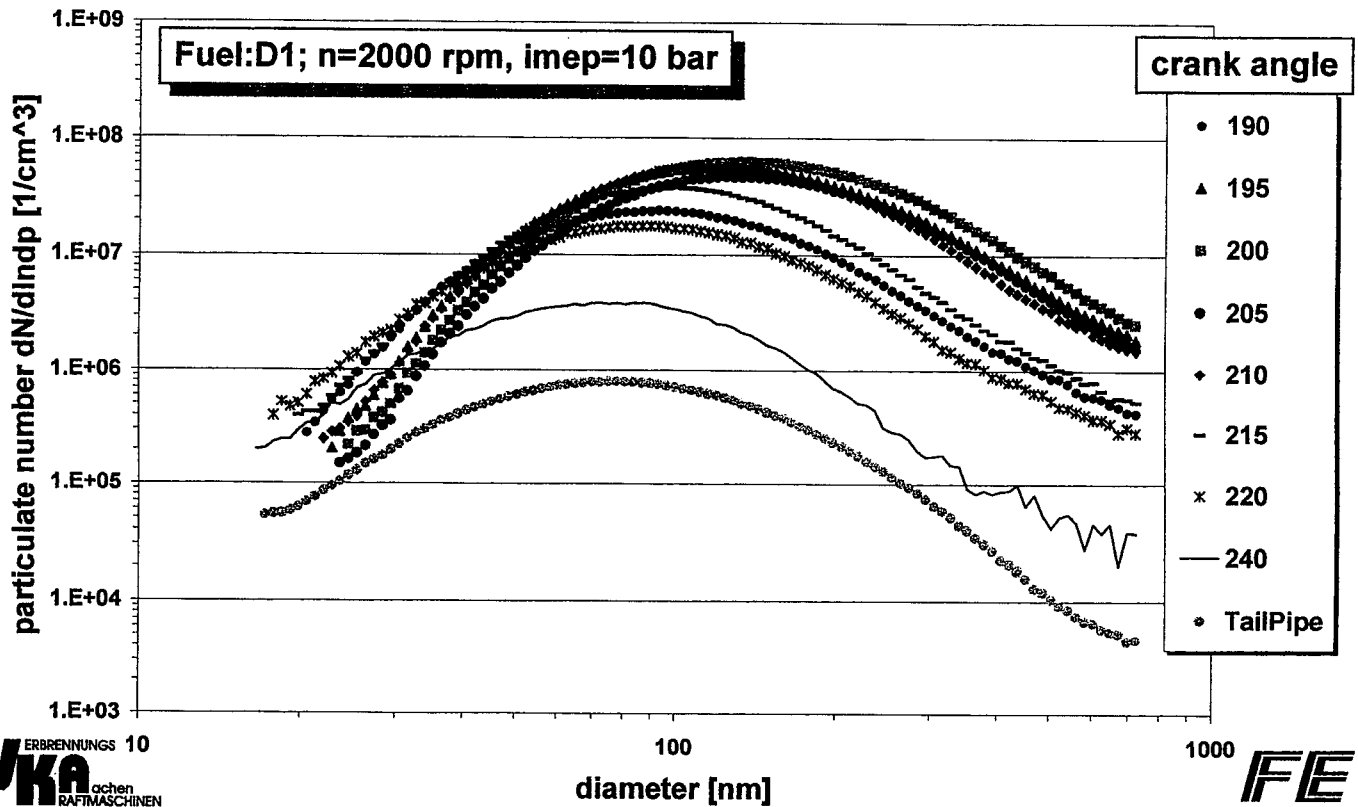
In-Cylinder Particle Size Distributions Combustion of soot during the Expansion Phase



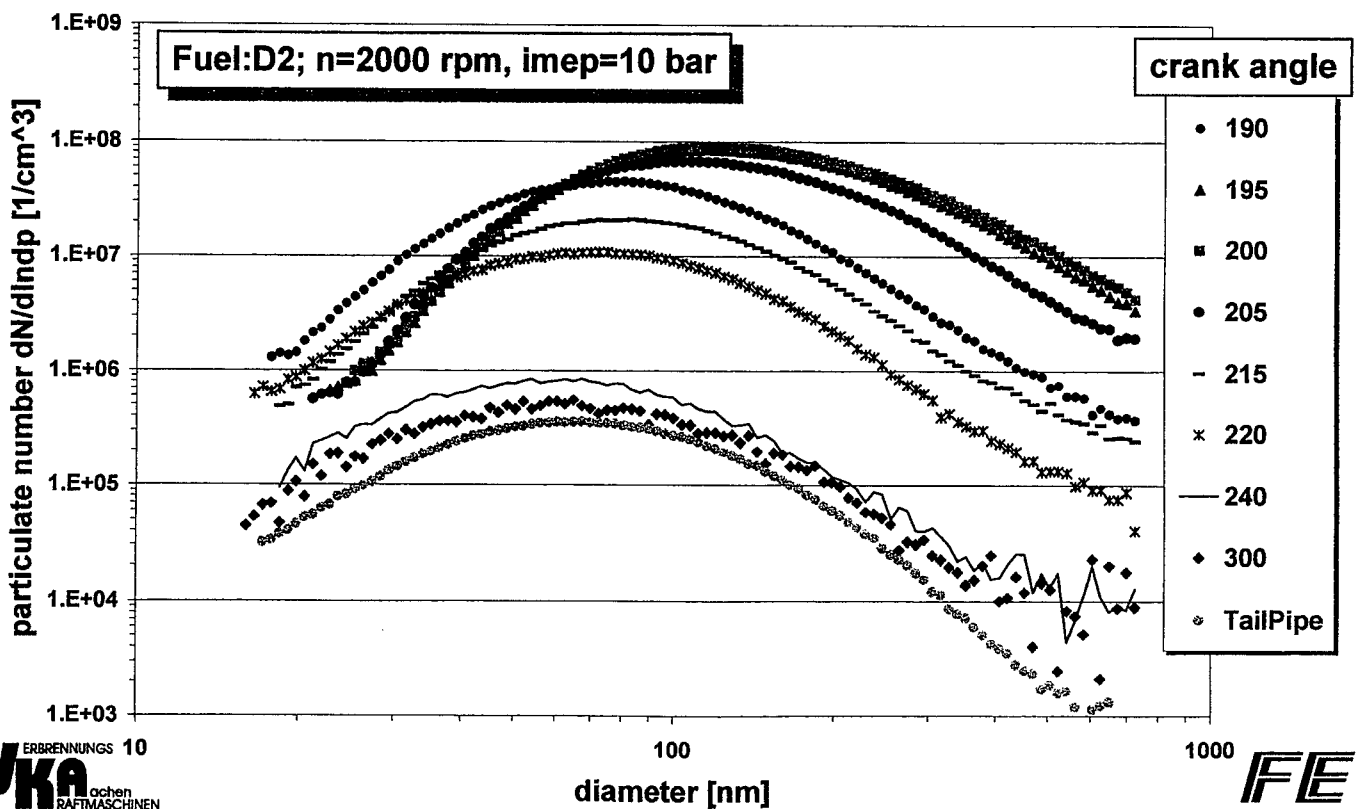
- Influence of O₂ containing fuel on the particle size distribution in the cylinder



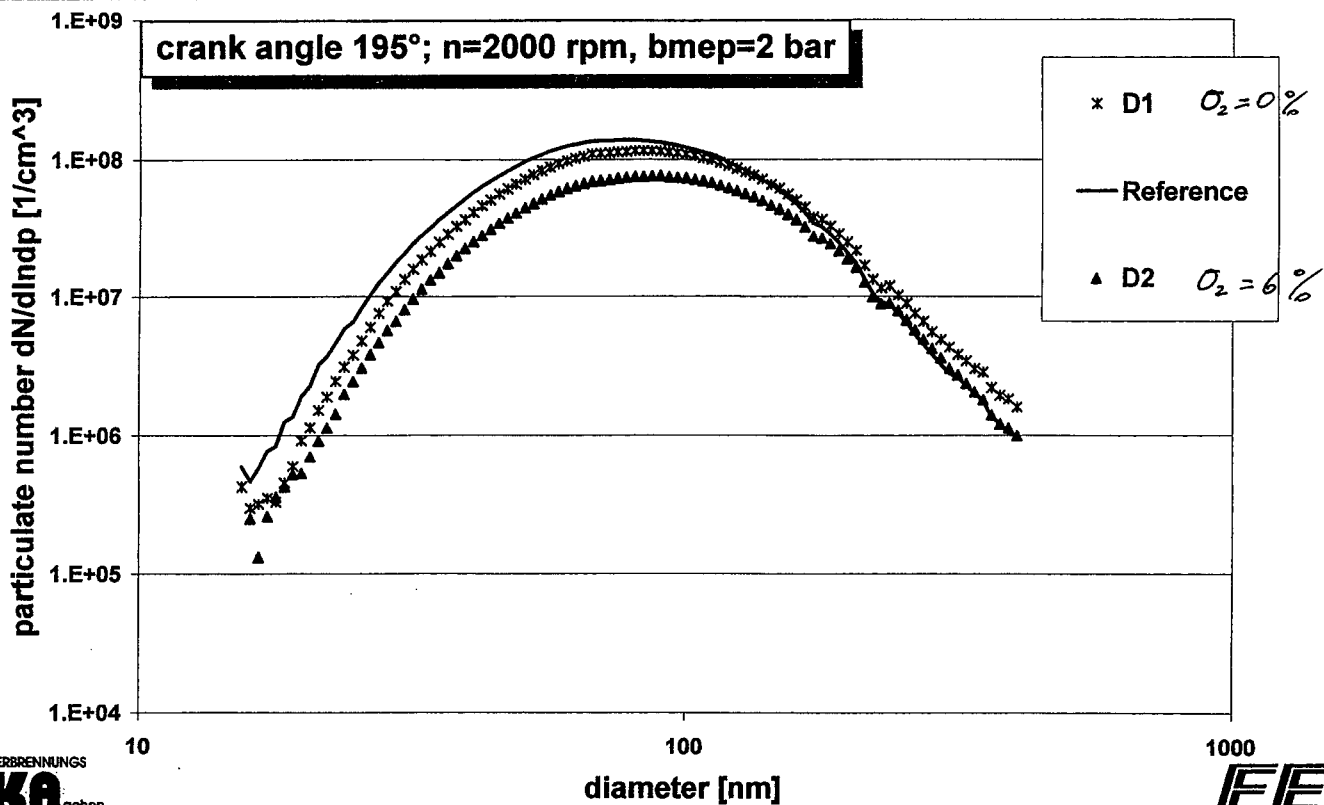
In-Cylinder Particle Size Distributions Combustion of soot during the Expansion Phase



In-Cylinder Particle Size Distributions Combustion of soot during the Expansion Phase



In-Cylinder Particle Size Distributions Comparison of Different Fuels



Conclusions

- Small particle formation during the injection and first combustion phase
- Particle number maximum at the end of the combustion phase
- Particle oxidation significant between about 210 °CA and 260 °CA (expansion phase)
- Primarily oxidation of "large" particles
- Increase of "small" particles during the particle oxidation phase at low load
- In-cylinder particle size distribution for > 260 °CA nearly equal to engine out emissions
- O₂ containing fuels reduce the particle number in the cylinder