

Characterization of Particle Size and Number Emissions from a HCCI Engine Operating on Diesel Fuel

Imad A. Khalek, Ph.D.

Southwest Research Institute, USA

10th ETH Conference on Combustion Generated
Nanoparticles, Zurich, Switzerland, 21-23 August, 2006

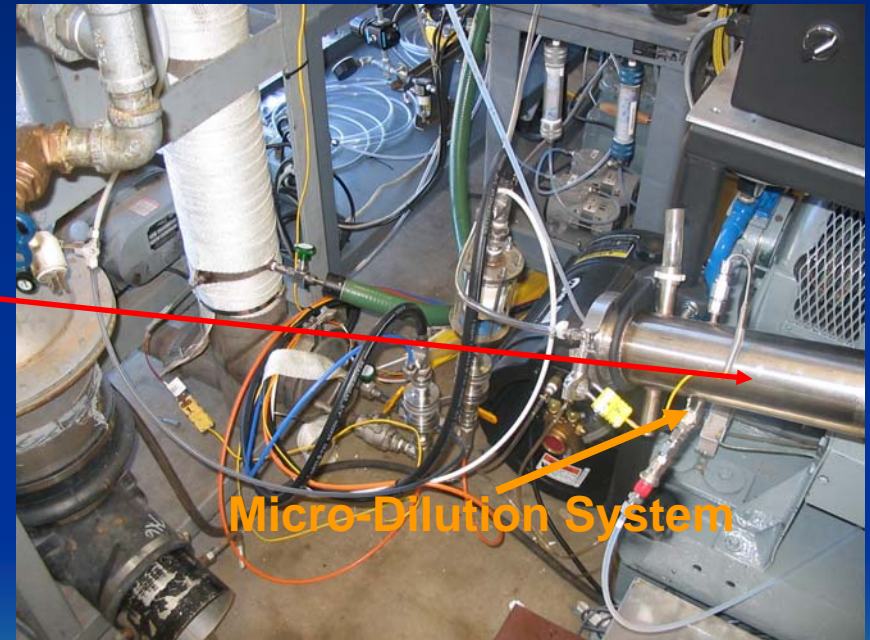
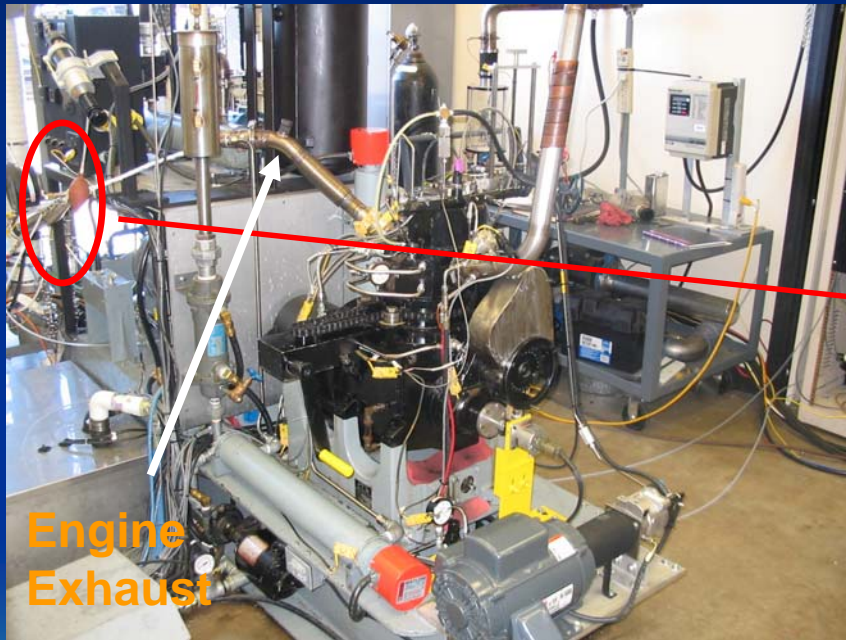
Background

- Homogenous charge compression ignition engine is a subject of intensive research efforts due to its very low engine-out NO_x and “soot” or solid particle emissions.
- However, engine-out emissions contain high levels of CO, HC, and semi-volatile particles
- This research does not cover engine emissions from a state-of-the-art HCCI engine, but the information obtained here is an indication of a concern in the area of volatile particle emissions from HCCI

Objectives

- The objective of this work was to characterize unregulated emissions from a single cylinder engine operating in a HCCI mode using US 2D diesel fuel. The emission measurement included size and number distribution, which is the main focus of this presentation

Variable Compression Ratio Single Cylinder Research Engine

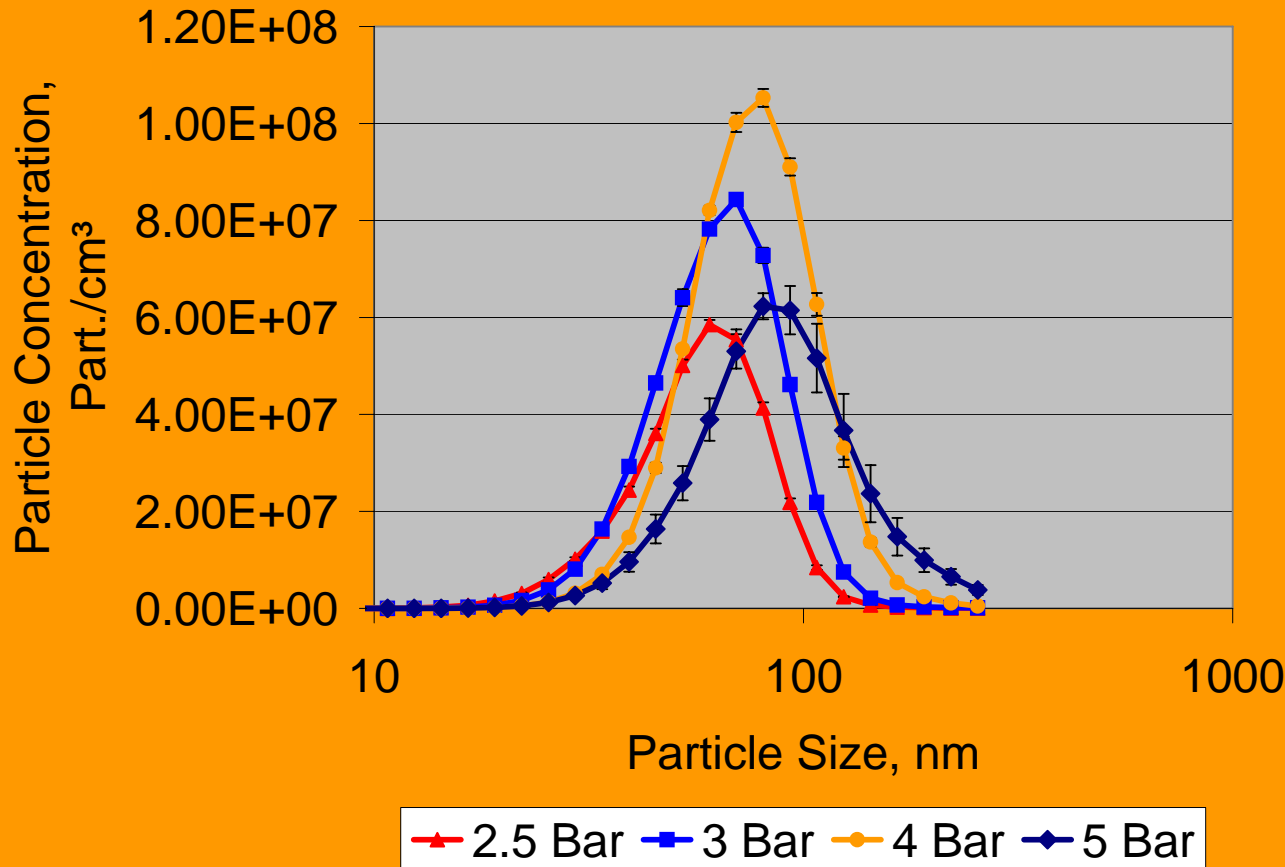


Dilution ratio was on the order of 50, with a residence time of one second

Test Matrix

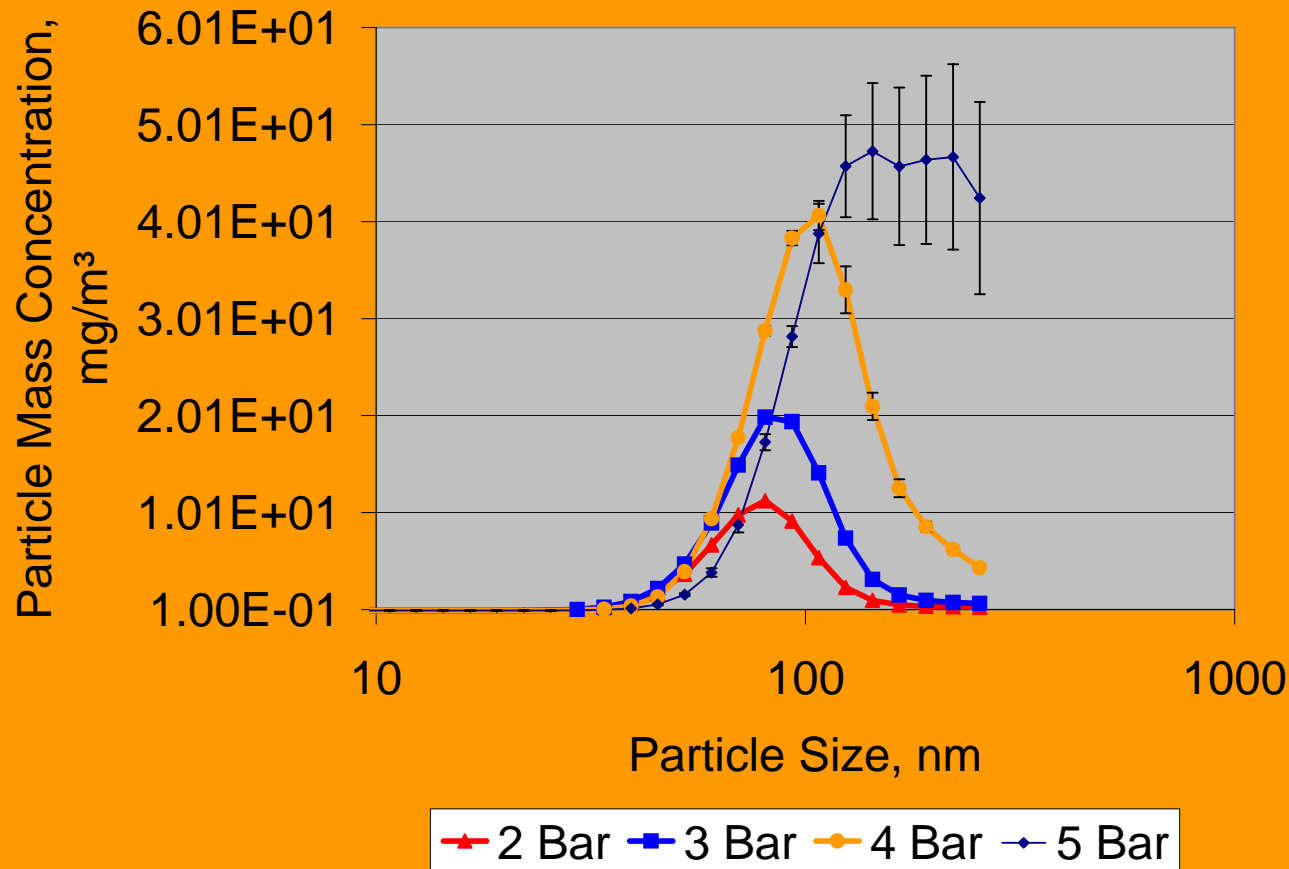
Engine Speed, rpm	Load/IMEP, bar	MAP,, kPa	MAT, deg C	Oil Temp, deg C	Coolant Temp, deg C	Compression Ratio	Peak Pressure, bar	Location PP degCA bTDC
1200	5.0	100	50	90	90	10.9	55.7	2.2
1200	4.0	100	50	90	90	13.3	59.7	2.5
1200	3.0	100	50	90	90	13.9	54	3.2
1200	2.5	100	50	90	90	14.7	52.5	4.0

Particle Number-Weighted Size Distributions



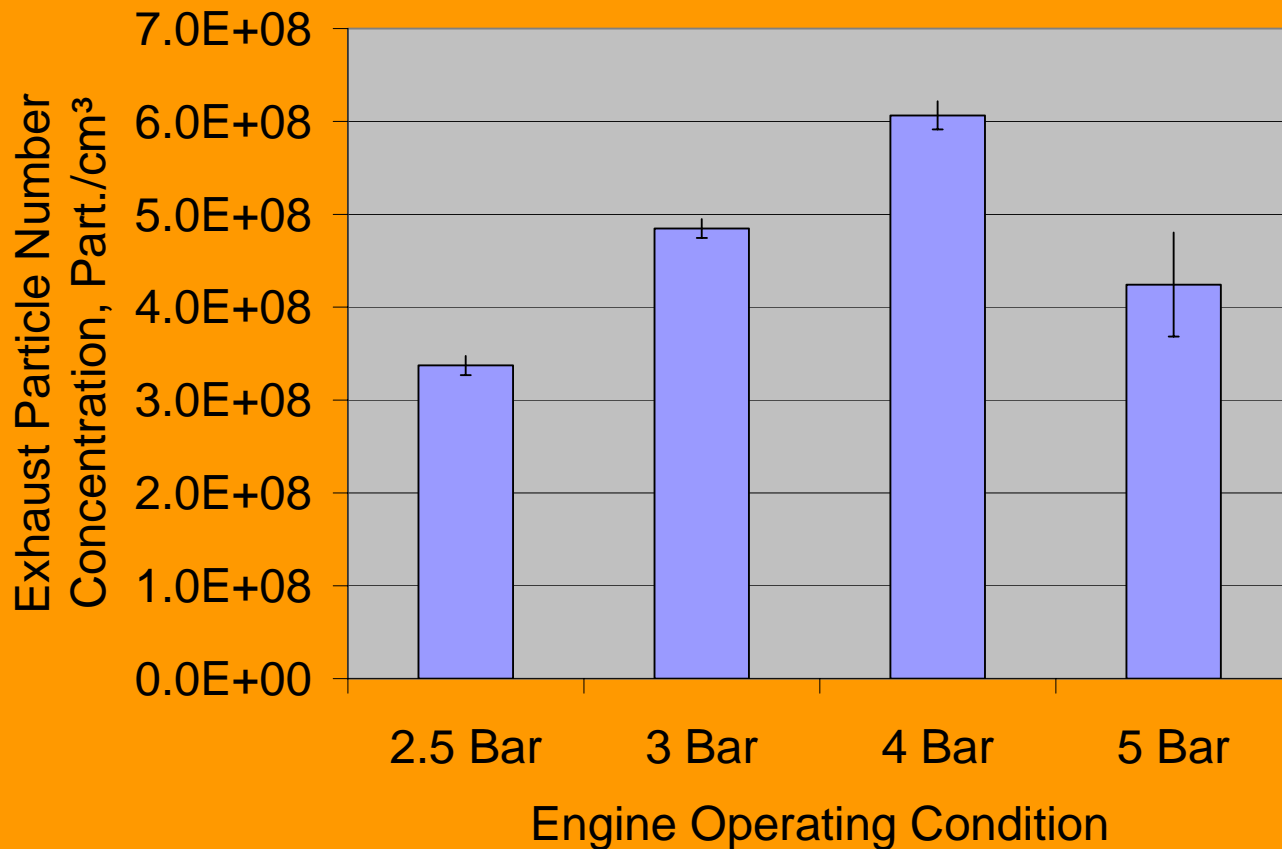
Particle Number-Weighted Size Distributions are similar to those observed in diesel exhaust. The distributions are monomodal in nature; this is likely due to high level of particle growth.

Particle Mass-Weighted Size Distributions



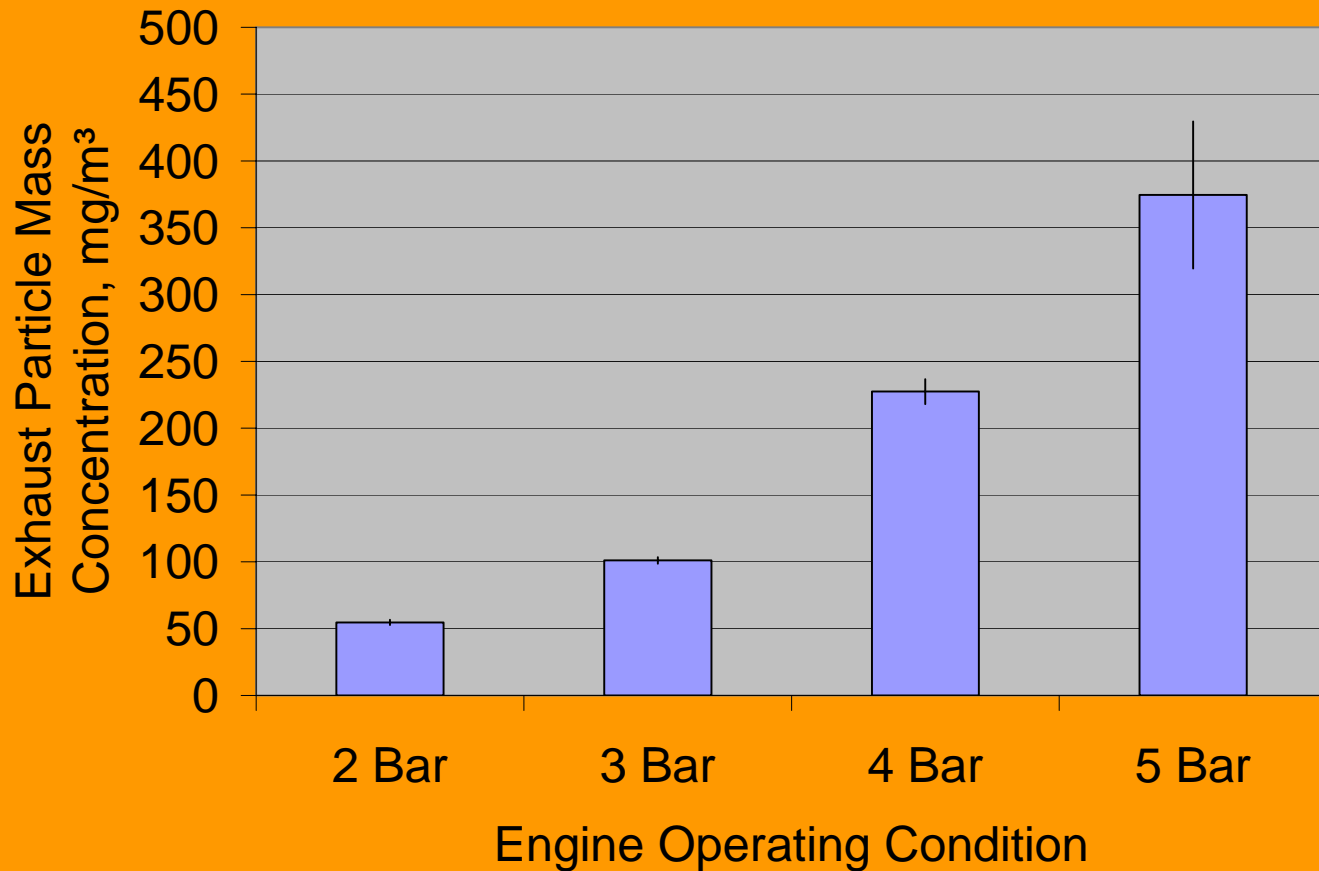
Engine was unstable at 5 Bar and produced no distinct mode of the size distribution on a mass basis

Exhaust Particle Number Concentration



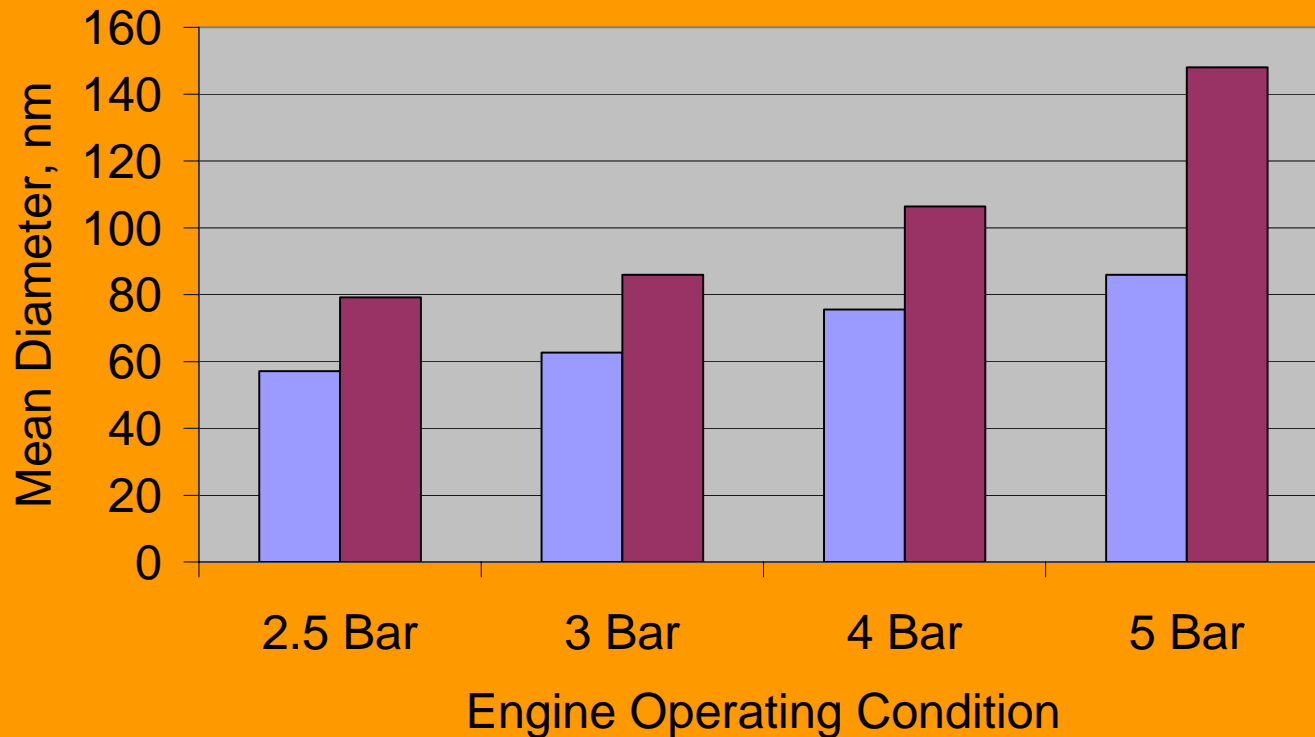
Number Concentration were high. The number concentration level is much higher than that typically observed in diesel engines. Generally, when a diesel engine emits such a high concentration, the distribution is bi-modal with very high number of nanoparticles.

Exhaust Particle Mass Concentration



Exhaust Mass Concentration is fairly high. It is generally higher than that observed in current technology diesel engine without aftertreatment. But, the volatile fraction of PM in this case may be higher than that of a diesel engine.

Number and Mass Mean Diameter



■ Geometric Number Mean Diameter
■ Geometric Mass Mean Diameter

Number and Mass Mean Diameter are similar to that of current engine-out diesel engines

Qualitative Assessment of Engine Exhaust PM for HCCI Operation

Primary and Backup Filter



Engine Exhaust Stack



Conclusions

- This limited work shows very high number and mass emissions from a HCCI engine operating on diesel fuel.
- However, it is important to note that this engine may not be representative of a production or a more advanced HCCI. Furthermore, this engine was not equipped with any aftertreatment device such as an oxidation catalyst that could potentially lower the precursor of particle formation.
- This work projects that particle number emissions from HCCI engines cannot be overlooked. More investigations are needed in this area. More publications are also desired.